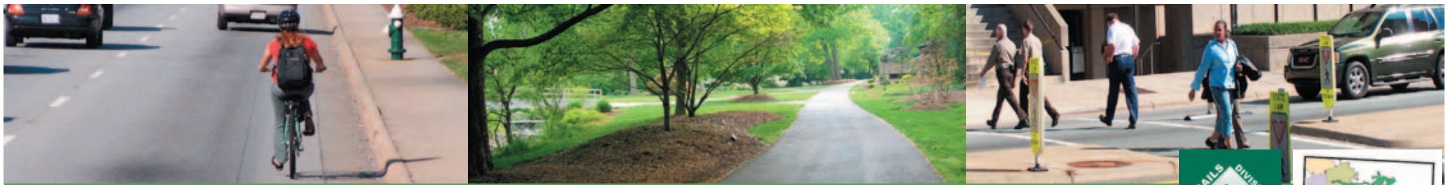


Appendix C: Design Guidelines

Introduction

The design guidelines featured here have been tailored to meet the specific facility development needs of Greensboro's greenway, bicycle, and pedestrian system. It is the intent of this Plan to comply with the Americans with Disabilities Act (ADA) and provide an accessible network. These guidelines provide a variety of facility ideas and serve as minimum standards for facility development. These guidelines are not a substitute for a more thorough examination and detailed landscape architectural and engineering evaluation of each project segment.

The guidelines adhere to national design standards as defined by the American Association of State Highway Transportation Officials (AASHTO), ADA, Designing Sidewalks and Trails for Access: Part 2 and the Manual on Uniform Traffic Control Devices (MUTCD). Should the national standards be revised in the future and result in discrepancies with this chapter, the national standards should prevail for all design decisions.

For more in-depth information and design development standards, the publications listed below should be obtained and consulted by the City of Greensboro. It is advised that the publication <u>Designing Sidewalks and Trails for Access: Part Two - Best Practices Design Guide</u> be specifically consulted when making ADA accessibility design decisions.

<u>Greenways: A Guide to Planning, Design and Development</u>
Published by Island Press, 1993
Authors: Charles A. Flink and Robert Searns
www.greenways.com

<u>Trails for the Twenty-First Century</u>
Published by Island Press, 2001
Authors: Charles Flink, Robert Searns, Kristine Olka
www.greenways.com

<u>Guide to the Development of Bicycle Facilities</u>
Updated in 2000 by the American Association of State Highway and Transportation Officials (AASHTO).
Available from FHWA or AASHTO
www.aashto.org/bookstore/abs.html

<u>North Carolina Bicycle Facilities Planning and Design Guidelines</u>
Published by the North Carolina Department of Transportation, Raleigh, NC. 1994

<u>Guide for the Planning, Design, and Operation of Pedestrian Facilities</u>
Published by the American Association of State Highway and Transportation Officials (AASHTO), 2004

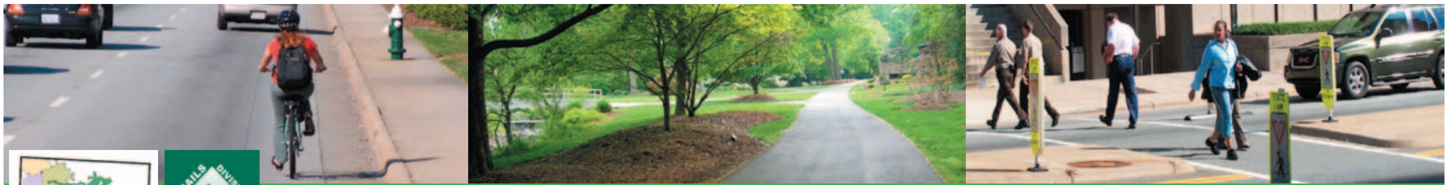
<u>Manual on Uniform Traffic Control Devices (MUTCD)</u>
Published by the U. S. Department of Transportation, Washington,DC, 2003

<u>Universal Access to Outdoor Recreation: A Design Guide</u>
Published by PLAE, Inc., Berkeley, CA, 1993

<u>Designing Sidewalks and Trails for Access: Part Two - Best Practices Design Guide</u>
Published by U.S. Department of Transportation, Washington, DC, 2001

Other useful web sites for information include:

- Rails-to-Trails Conservancy - www.railtrails.org
- National Park Service - www.nps.org
- U.S. Department of Transportation - www.walkinginfo.org and www.bicyclinginfo.org
- Trails and Greenways Clearinghouse - www.trailsandgreenways.org
- National Bicycle and Pedestrian Clearinghouse - www.bikefed.org/clear.htm

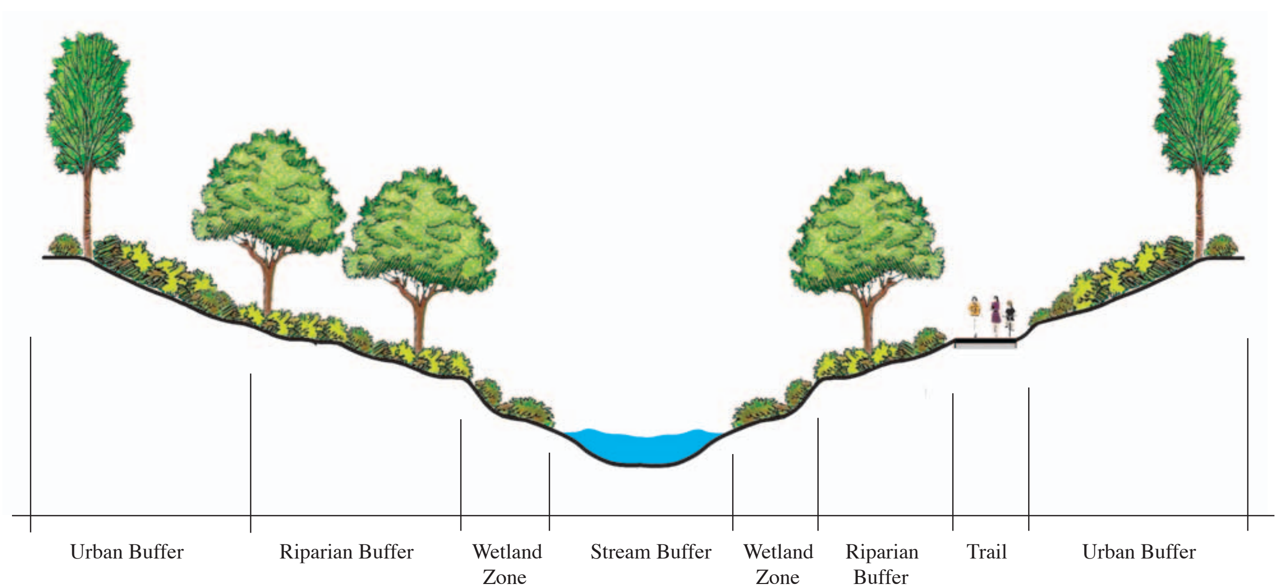


C1. Greenway Design Guidelines

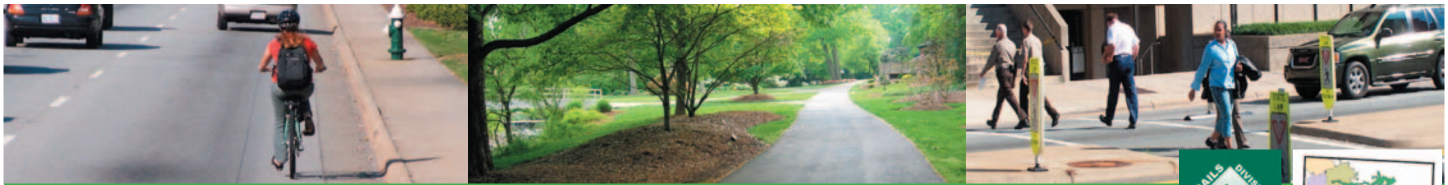
The following pages focus on design guidelines for greenways. It includes information on riparian buffers, corridor plantings, different trail treads, different types of greenway facilities, trailheads, signage, and other ancillary facilities

Riparian Buffers (Type I facility)

Riparian buffers serve many functions. They filter stormwater pollutants, help moderate stream flow, stabilize streambanks, moderate stream temperature, and provide aquatic and terrestrial habitat. The minimum recommendations should require that new developments maintain a 50' vegetated buffer on both sides of all intermittent and perennial streams, lakes and ponds. For the purpose of these recommendations, a waterbody exists if the feature is present on either the most recent version of the soil map or 7.5 minute quadrangle topographic map prepared by the United States Geological Survey (USGS). The recommended required buffers consist of two zones: a 30' undisturbed zone adjacent to each side of the waterbody, and a vegetated zone that extends from the outer edge of the 30' zone for a distance of at least 20'. These recommendations are consistent with the State level Neuse and Tar-Pam Basinwide Rules.



Buffers are required in water supply watersheds throughout the state as part of the Water Supply Watershed Management Program. The Division of Water Quality manages the program through oversight of local ordinances and monitoring of land use activities. Local water supply watershed programs must be approved by the NC Environmental Management Commission (EMC). The program requires local governments to adopt land use controls that include buffer protection. For low-density development, 30' buffers are required along perennial streams, and 100' buffers are required for high-density development.



For the purpose of greenway facility development, a minimum 50' buffer (150' preferred) as measured from the top of streambank is required to mitigate the damaging effects of flooding from storms, filter pollutants from overland flow and develop appropriately sized greenway trail facilities.

Many local governments throughout the state have applied the 50' buffer. Some have placed additional buffers up to 100' on their streams, according to their stream order.

As an alternative to the conventional method of prescriptive buffers, stream buffer widths can be varied according to ecological features of the watershed. Each buffer width would be site specific, depending on the following characteristics of the stream, riparian buffer and watershed:

- Slope
- Soil
- Hydrology
- Vegetation
- Water Quality
- Impervious Surface

Many bird species and other wildlife require a much larger buffer width than that required to protect water quality. For corridors designed primarily as habitat protection, a 300' undisturbed buffer is desirable.

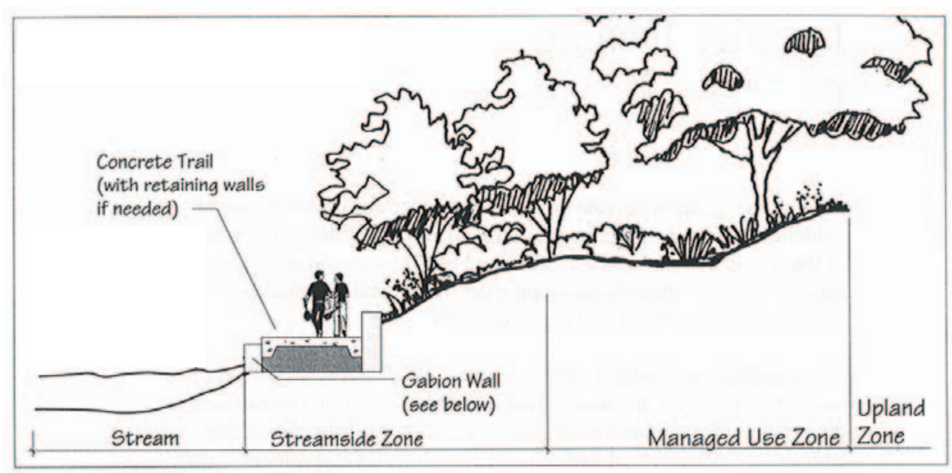
Corridor Planting

Some basic guides for planting in corridors is as follows:

- Efforts should be made to eliminate non-native invasive species, such as privet (Ligustrum sinense) from corridors.
- Native overstory and understory trees/shrubs should be replanted where vegetation is removed or harmed due to construction of parks, trails, etc. in greenway corridors or open space.
- Fallen trees should not be removed unless they obstruct trails or present danger. Otherwise, they should be left to decay naturally. Evergreens, conifers, and deciduous trees should all be used proportionally.
- Mast producing trees and shrubs with berries should be utilized as food for wildlife whenever possible.
- Flowering trees and shrubs can be used to draw attention to important intersections and entrances.
- Evergreen shade trees are needed near seating areas and picnic tables.
- Evergreen shrubs, such as wax myrtle, can help separate public areas from private residences.

Creekside Trail Tread

Creekside trails are located only in urban areas, where right-of-way constraints and channelized streams restrict trail development to the floodway. Creekside trails are designed to accommodate walkers, bicyclists, rollerbladers, and joggers. These multi-use trails are typically positioned directly adjacent to the stream channel and are therefore subject to frequent flooding. These trails require hard-paved surfaces of concrete to withstand high-velocity stream flows. Retaining walls or other structural elements may also be required for stable construction and to protect the trail from erosion and flood damage.

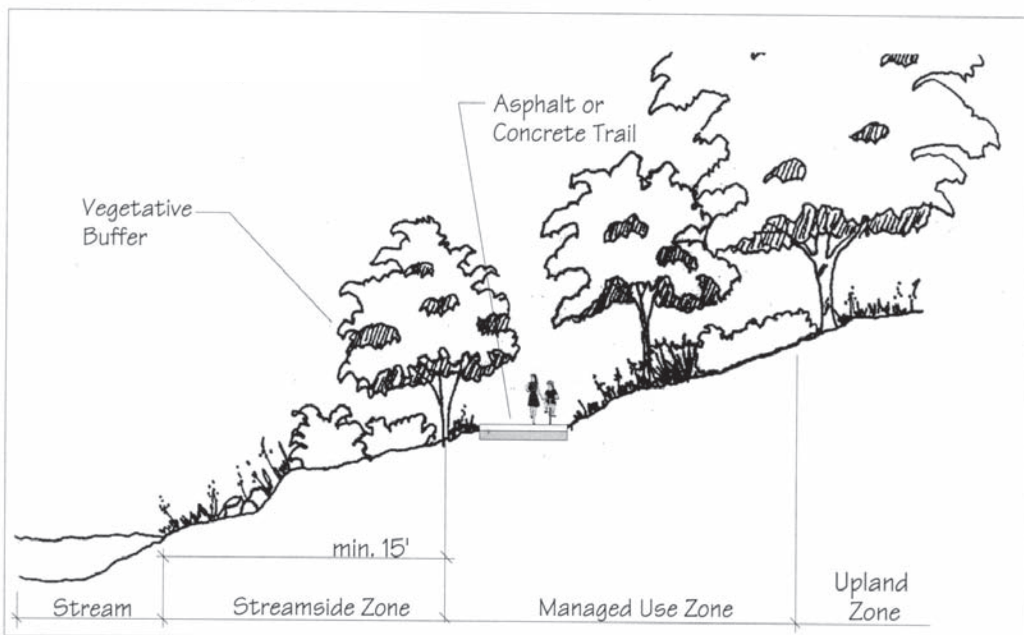


Typical Multi-Use Creekside Trail Cross Section

Creekside trails should be a minimum of 10' wide for multi-use trails. The installation of railings, benches, signage, and trash receptacles that could obstruct flow during storm events, should be carefully considered. Creekside trails must be designed and installed in a manner that minimizes their effect on flood waters and protects the amenities from flood damage. The use of retaining walls as seat walls is one way in which non-obtrusive amenities can be included on this type of trail facility. Special consideration should be paid to mitigating the impacts of trail construction on the natural environment.

Floodway Trail Tread

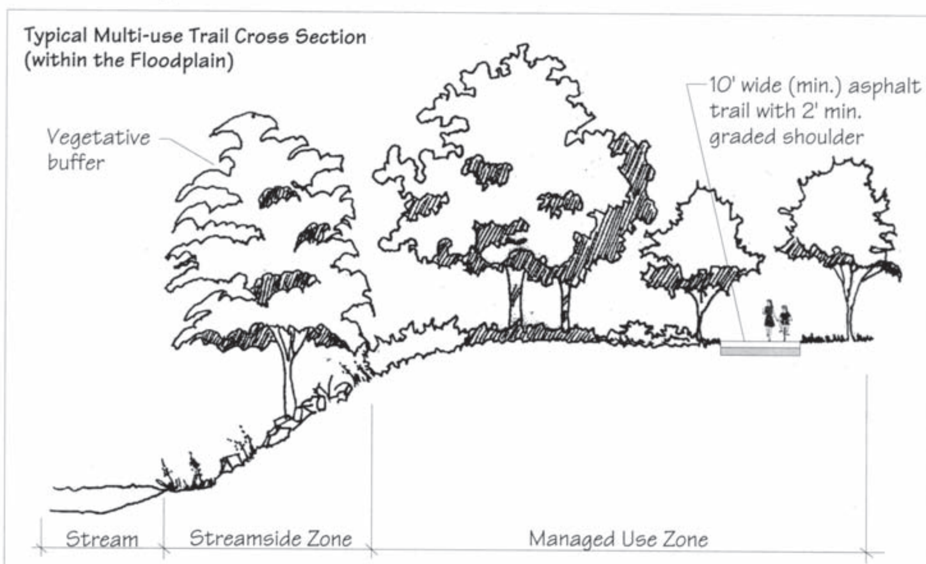
These multi-use trails are typically positioned within the floodway but not directly adjacent to streams. They are designed to accommodate a variety of users including walkers, joggers, cyclists, and rollerbladers. Some vegetative buffer between the stream and trail should be left intact. Like the streamside trails, trails within the floodway are subject to periodic flooding, however, not as frequently. These trails require paved surfaces of either asphalt or concrete depending on frequency of flooding and expected velocity of flow. A proper trail foundation is important and will increase the longevity of the trail. No soft shoulder should be constructed due to flood considerations. Special consideration should be given to the mitigation of negative impacts from trail development on the natural stream environment. Multi-use trails within the floodway should be built with a minimum width of 10 feet. All elements of the trail including the trail tread, railings, benches, and trash receptacles will be periodically flooded. The design and materials for these trails should be carefully selected to accommodate this factor.



Typical Multi-Use Trail Cross Section
(Within the Floodway)

Floodplain Trail Tread

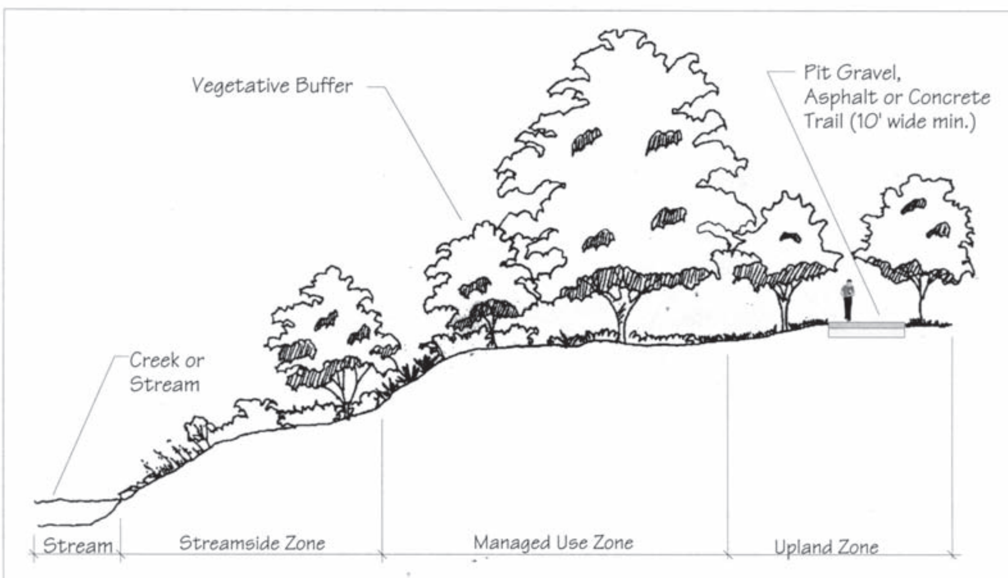
Like the floodway and creekside trails, multi-use trails within the floodplain are designed to accommodate uses such as walking, jogging, cycling, and rollerblading. These multi-use trails are positioned outside the floodway but within the floodplain. Significant vegetative buffers between the stream and trail should be left intact. These trails will be subject to occasional flooding during large storm events, and it is recommended that they be built with paved asphalt. However, an aggregate stone surface may be adequate in some locations. Multi-use trails within the floodplain should be built to a minimum width of 10' (12' to 14' is preferred). The graphics below illustrate two suitable pavement cross sections that can be used to build multi-use trails within the floodplain.



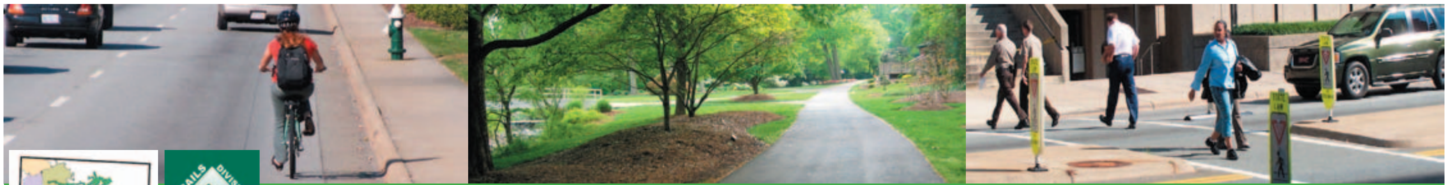
Typical Multi-Use Trail Cross Section
(Within the Floodplain)

Upland Trail Tread

Upland multi-use trails are typically positioned completely outside designated floodplains. Significant vegetative buffer between any streams and the trail should be left in tact. It is recommended that these trails be built with paved asphalt or aggregate stone, depending on the preference of local user groups. Upland multi-use trails should be built to a minimum width of 10', though 12' is preferred.

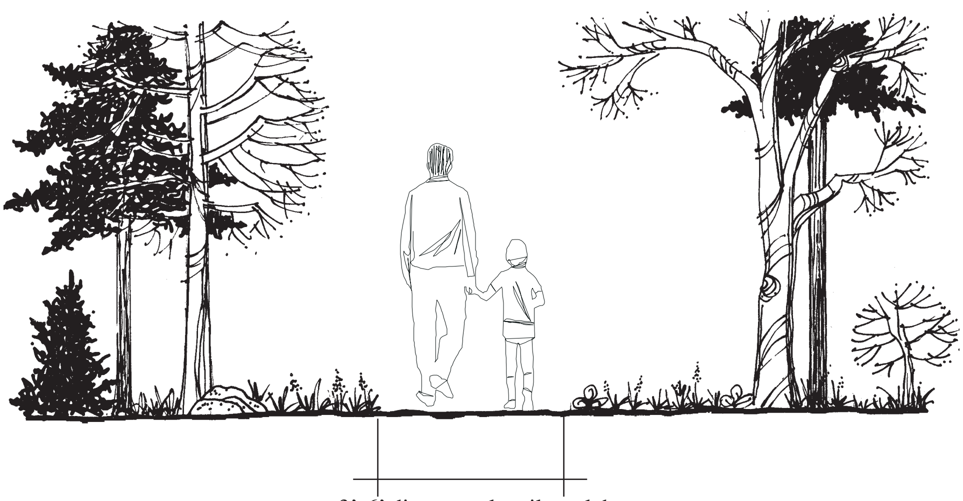


Upland Trail Cross Section



Footpath/Hiking Trail (Type II & III facilities)

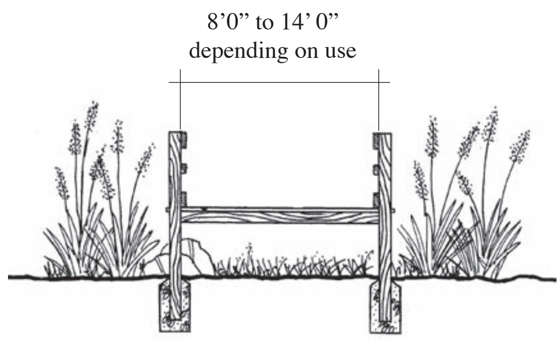
Footpaths or hiking trails are designed to accommodate pedestrians and are not intended for cyclists or other wheeled users. These natural surface trails typically make use of dirt, rock, soil, forest litter, pine mulch and other native materials for the trail surface. Preparation varies from machine-worked surfaces to those worn only by usage. This is often the most appropriate surface for ecologically sensitive areas. The construction of these trails focuses on providing positive drainage for the trail tread and should not involve extensive removal of existing vegetation. Timbers may be used for steps along steep slopes. These trails vary in width from 3 feet to 6 feet and vertical clearance should be maintained at 9 feet. Footpath/Hiking trails are most commonly found within the streamside zone.



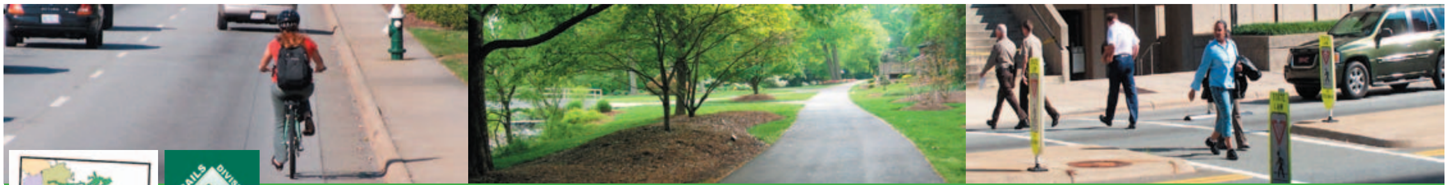
3’-6’ dirt, gravel, soil, mulch,
leaf litter, etc. trail surface

Boardwalk Trail Tread

Boardwalks, or wood surface trails, are typically required when crossing wetlands or poorly-drained areas. While boardwalks can be considered multi-use trails, the surface tends to be slippery when wet and may not be suitable for wheeled users. Boardwalks intended for multiple uses should be a minimum of 14 feet wide. However, boardwalk trails limited to pedestrian use only can be as narrow as 8 feet. If maintenance vehicles use the boardwalk for maintenance access, it should be a minimum of 14 feet.



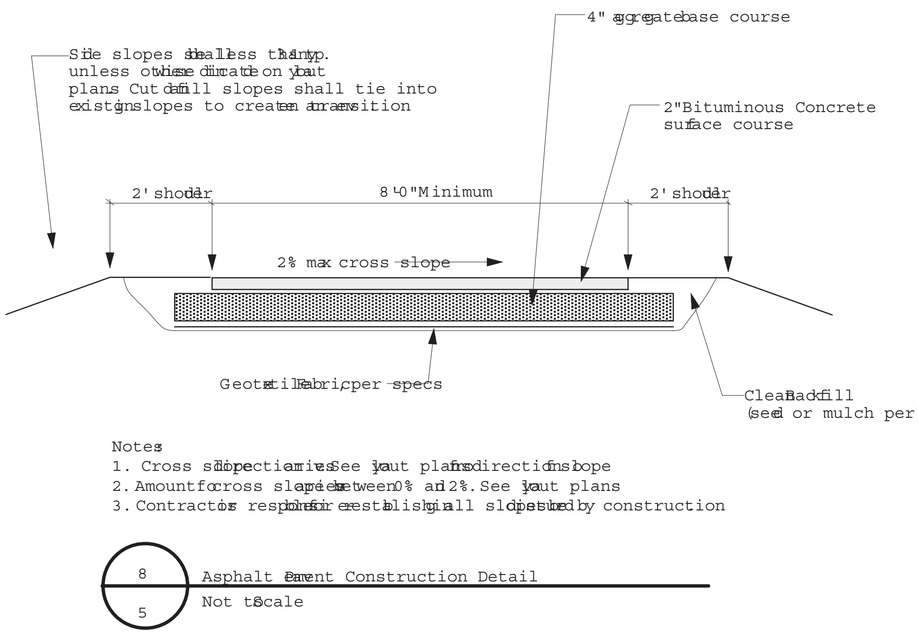
Wood surfaced trails are usually composed of sawn wooden planks or lumber that forms the top layer of a bridge, boardwalk or deck. The most commonly used woods for trail surfacing are exposure- and decay- resistant species such as pine, redwood, fir, larch, cedar, hemlock and spruce. Wood is a preferred surface for special applications because of its strength and comparative weight, its aesthetic appeal and its versatility. Synthetic wood, manufactured from recycled plastics, is now available for use as a substitute in conventional outdoor wood construction. While these products are more expensive than wood, the recycled plastic lasts much longer, does not splinter or warp and will not discolor. They can, however, be more difficult to maintain if vandalism is a problem in the area.



Paved Multi-Use Trail (Type IV facility)

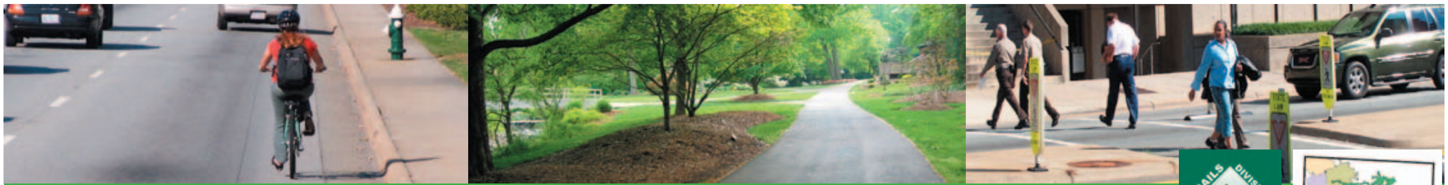
Typical pavement design for a paved, off-road, multi-use trail should be based upon the specific loading and soil conditions for each project. These asphalt or concrete trails should be designed to withstand the loading requirements of occasional maintenance and emergency vehicles. In areas prone to frequent flooding, it is recommended that concrete be used because of its excellent durability. For the Greenville Greenway system, it is anticipated that asphalt will be sufficient.

One important concern for asphalt trails is the deterioration of trail edges. Installation of a geotextile fabric beneath a layer of aggregate base course (ABC) can help to maintain the edge of a trail. It is important to provide a 2' wide graded shoulder to prevent trail edges from crumbling.



The minimum width for two-directional trails is 10', however 12'-14' widths are preferred where heavy traffic is expected. Centerline stripes should be considered for paths that generate substantial amounts of pedestrian traffic. Possible conflicts between user groups must be considered during the design phase, as cyclists often travel at a faster speed than other users. Radii minimums should also be considered depending on the different user groups.

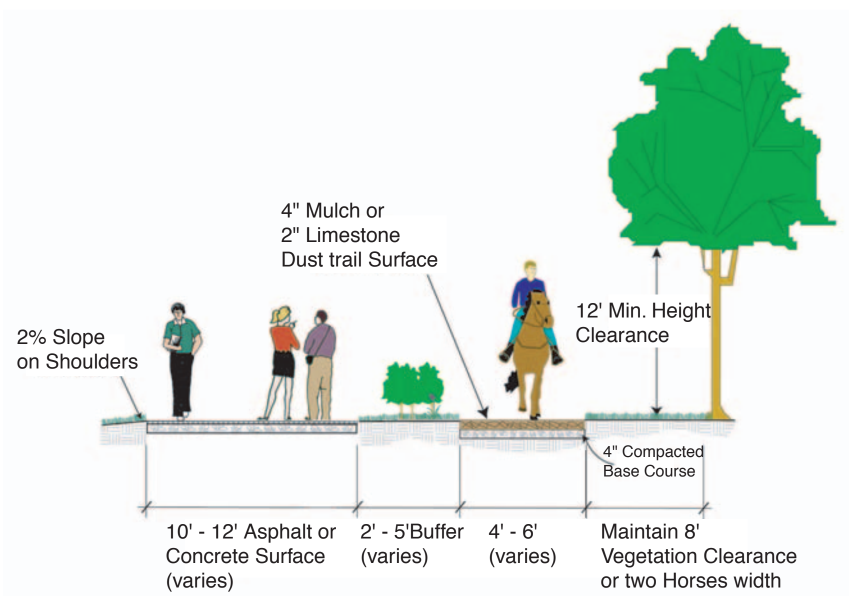
Asphalt is a hard surface material that is popular for a urban trails. It is composed of asphalt cement and graded aggregate stone. It is a flexible pavement and can be installed on virtually any slope. Concrete surfaces are capable of withstanding the most powerful environmental forces. They hold up well against the erosive action of water, root intrusion and subgrade deficiencies such as soft soils. Most often, concrete is used for intensive urban applications. Of all surface types, it is the strongest and has the lowest maintenance requirement, if it is properly installed.



Dual Trail Tread

Dual tread trails are suggested on multi-use trail systems where the different uses may conflict, such as equestrians and bikers. If hard surfacing is being used on the multi-use trail, a softer, 5'-wide tread for horses should be considered. Mulch, dirt, stabilized dirt or limestone dust can be used. Hard surfaces, such as concrete and asphalt are undesirable for equestrians because they can injure horses' hooves. Granular stone may also present problems because it can get stuck in horse hooves.

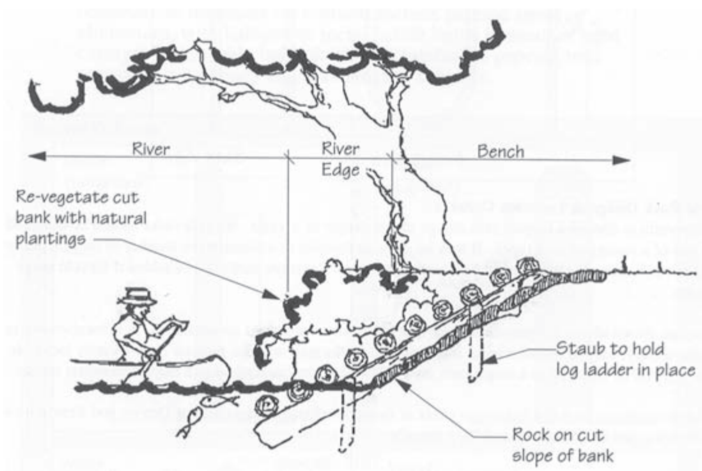
Vertical clearance for equestrians should be at least 10', with a horizontal clearance of at least 5'. Low-hanging tree limbs should be cut flush with the trunk. Leaves, branches and other protrusions that could injure the horse, rider or gear should be removed. Within the tread, stumps, large rocks and other debris should be cleared. Sight distances for equestrians, who usually travel between 4 and 6 miles per hour, should be at lest 100'.



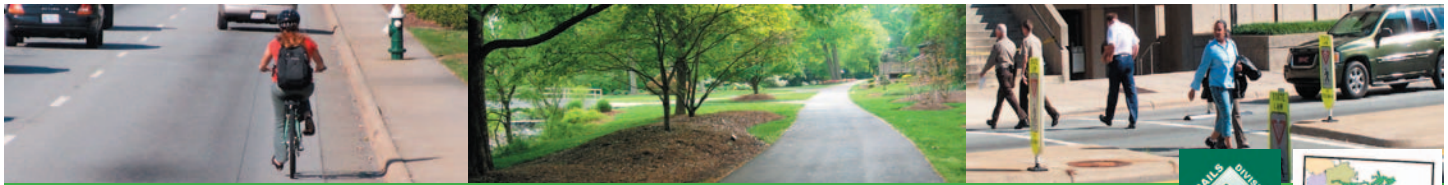
Typical Equestrian and Pedestrian Trail Cross Section

Water Based Trail (Type VI)

This designation applies to those rivers and streams that can successfully accommodate and/or which are designated to support canoeing, kayaking and boating. Water based trails can be designated with features and facilities that make this activity more enjoyable including signage systems, improved rapids, safety systems, and access points. Rental outfits could be established at put in/take out points. It is recommended that an official access point be located every 10 river miles along a paddle trail.



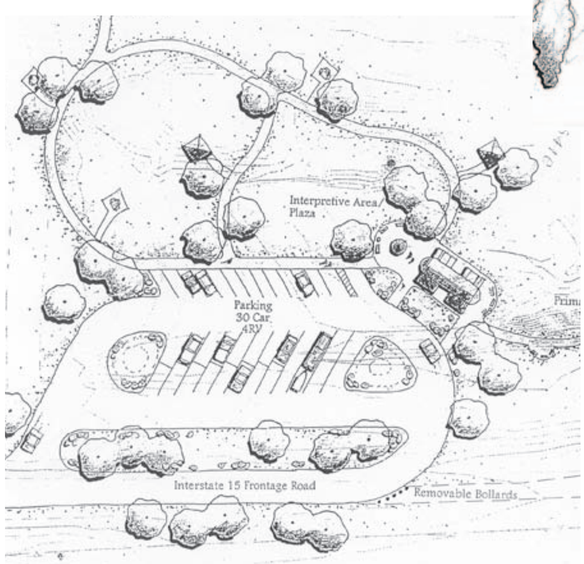
Small Boat Access



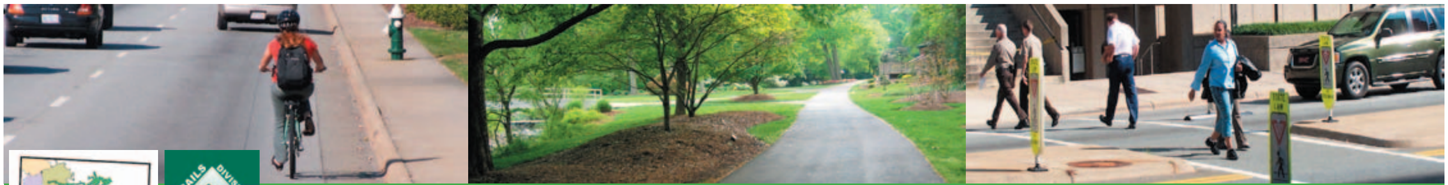
Major and Minor Trailheads

Trail heads should be installed throughout the greenway system to give the public access. These serve as points of formal public entry into the greenway system that may provide certain related public facilities such as parking, restrooms, drinking fountains, trail signage, etc. A mix of major and minor trail heads is suggested. Major trail heads should be located areas where there is expected to be significant use. An exhibition building or an interpretive exhibit may be incorporated, along with restrooms, water fountains, picnic tables, parking, signage, etc. Minor trail heads can be used to connect a smaller number of people to surrounding trails.

Typical Minor Trailhead Plan View



Typical Major Trailhead Plan View



Restrooms

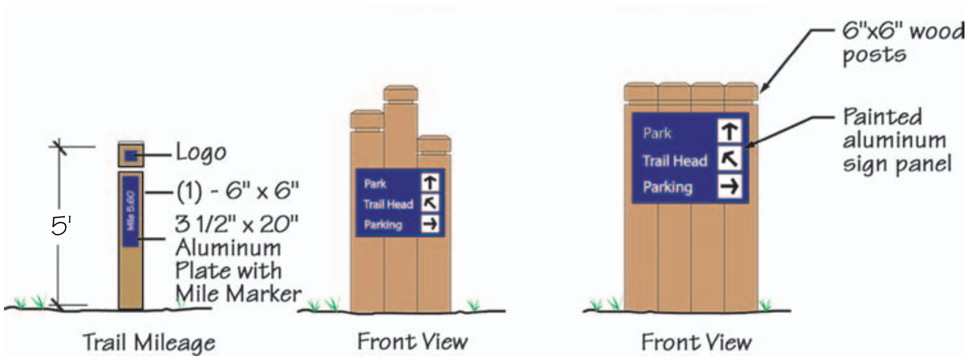
Public amenities such as phones and restrooms should be located and concentrated at the confluence of vehicular and pedestrian traffic. ADA accessible restrooms should be placed at major trail access points in order to accommodate trail users. Where possible, other uses should be incorporated into the structure, such as storage for maintenance equipment. These structures should be located adjacent to thoroughfares for security, maintenance and access to utility hookups. They should also make use of natural light and ventilation as much as possible.

Typical Restrooms

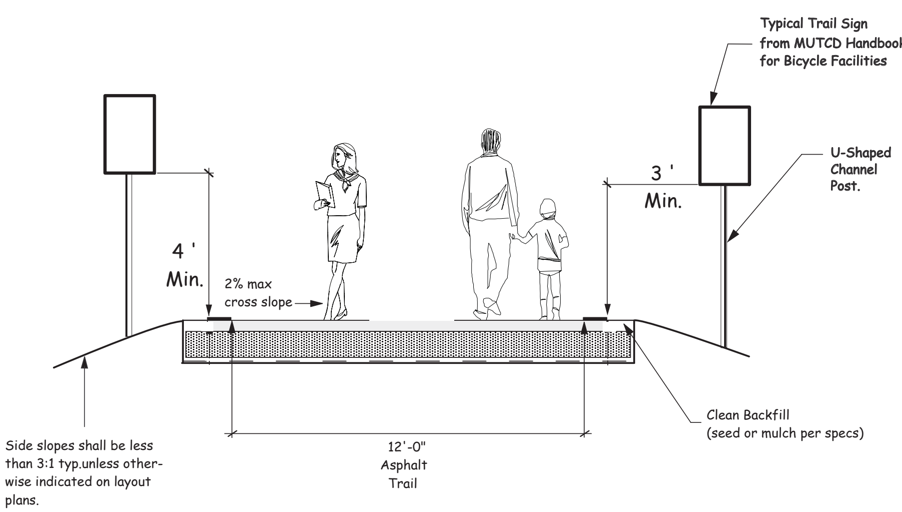
Waterless Restroom Option

Directional Signage

Some examples can be seen below of typical directional signage. Whatever style the community chooses, there should be a similar appearance or theme throughout the system. Trail rules should also be posted at entry points to the system as should some sort of mileage notation.



Where signs are located along the greenways is important so that their visibility is maximized. Maintaining a certain distance from the actual tread is important for safety reasons.



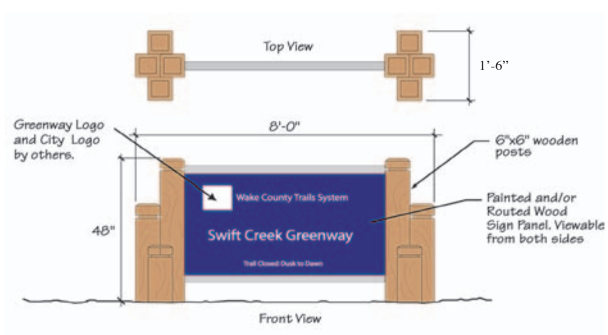
Typical Signage Location

Interpretive Signage

Greenways can benefit from signs that explain the natural, cultural, and historic value of a site. This sort of interpretive signage helps users understand the many values of the greenway system and can be valuable tools in using the greenway system as an educational tool.

Entry Signage

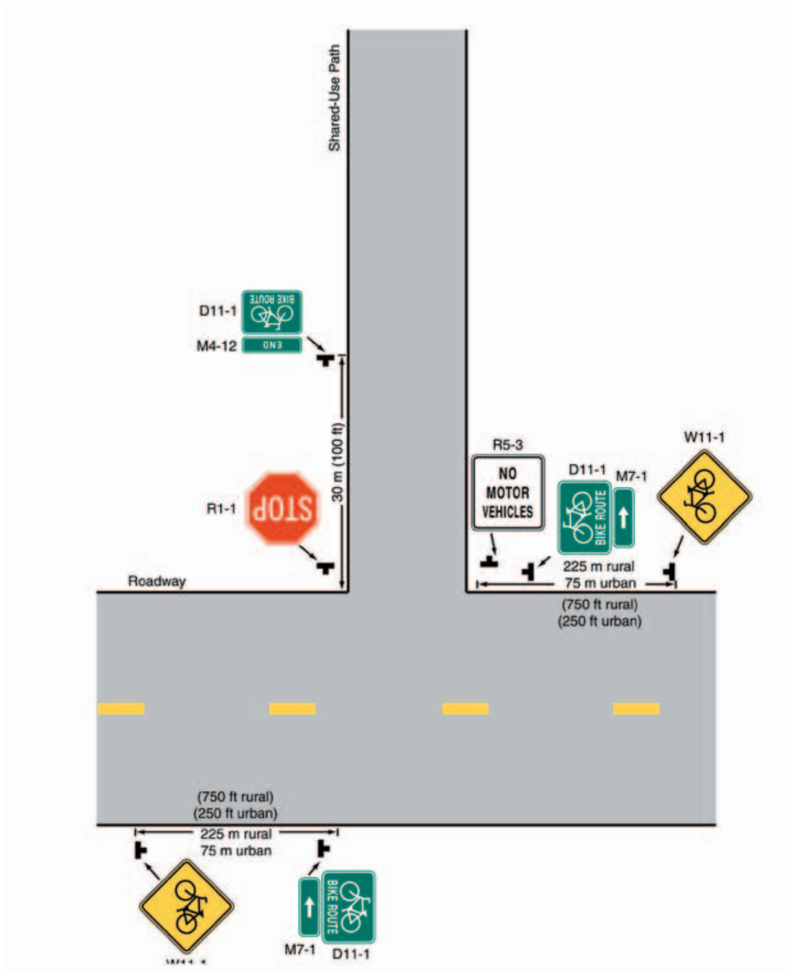
Proper trail identification at trail terminal point and major intersections is important in the development of a comprehensive trail network. Greenway entry signage may also include mileage to provide users with a reference as to how far he or she has traveled, and the remaining distance to specific destinations.



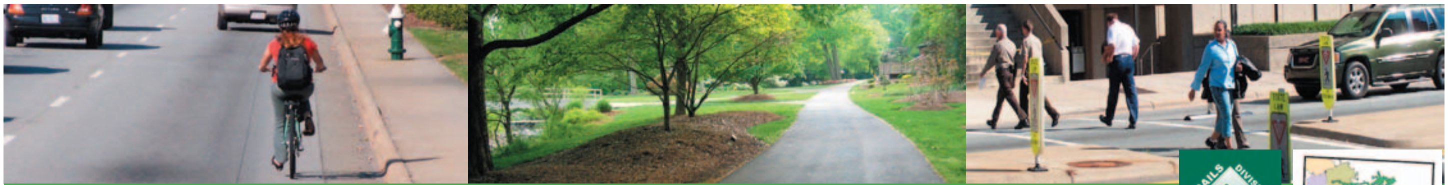
DOT Bike Signage

The US Department of Transportation's Manual on Uniform Traffic control Devices (MUTCD) specifies standard signage for all transportation configurations. Chapter 9 of that document is dedicated to Traffic controls for Bicycle Facilities. The entire document is available online at http://mutcd.fhwa.dot.gov/

It is recommended that this manual be consulted regularly regarding the proper placement of bicycle (and pedestrian) related traffic signage. Below is one example form the document about proper placement of bicycle related signs.

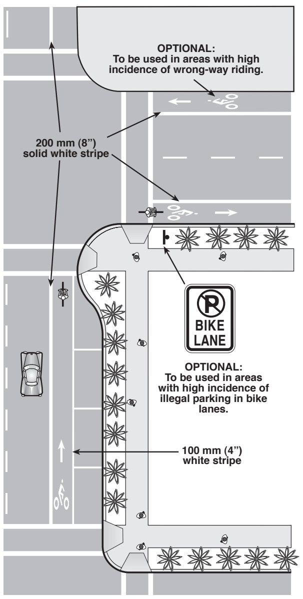


Signage Placement for Bicycle Facilities

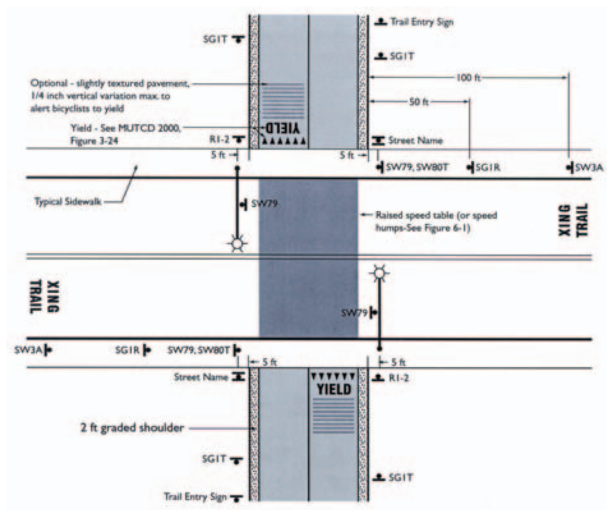


Trail Crossings

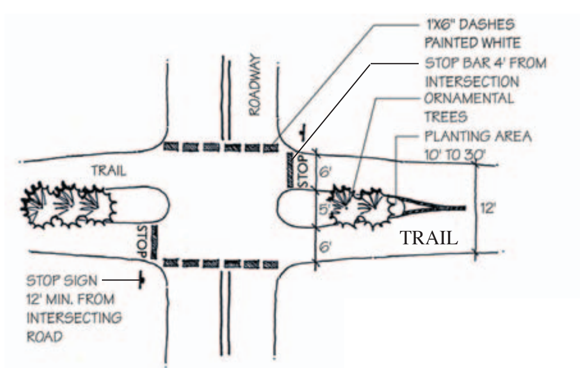
The images below present detailed specifications for the layout of intersections between trail corridors and roadways. Signage rules for these sorts of intersections are available in the MUTCD as well.



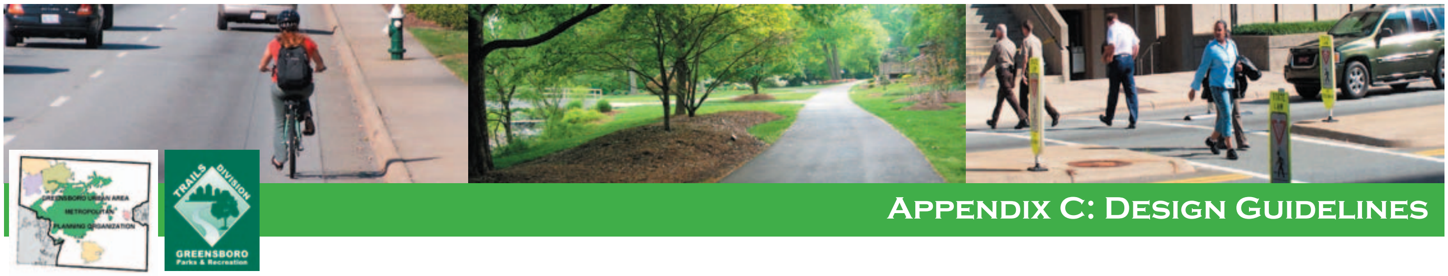
Typical Signage Layout for Intersection



Typical Trail Crossing at Local Street (from Contra Costa County Trail Design Guidelines)



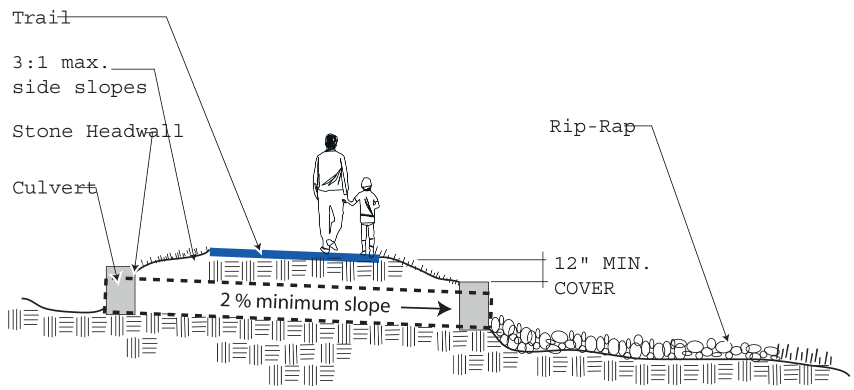
Typical Perpendicular Trail and Road Intersection



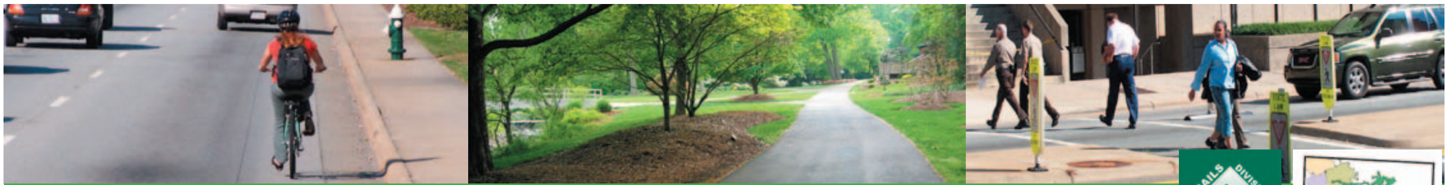
Trail Culvert

Proper installation of trail culverts is important to ensure proper stormwater runoff drainage, trail user safety, and longevity of the trail surface. Pipe length, diameter and material specifications will vary depending on specific site needs. Two materials typically used for trail culverts are reinforced concrete pipe (typically required when the trail is within NCDOT Right of Way), and High Density Polyethylene (HDPE) recycled plastic pipe.

Plastic pipes are typically less expensive on a per foot basis. Outlet protection varies per site needs and in some cases a flow spreader may be required at the outlet location. Rock check dams can be placed after the outlet to slow and filter drainage. The graphic below outlines proper installation parameters for greenway trail culverts.

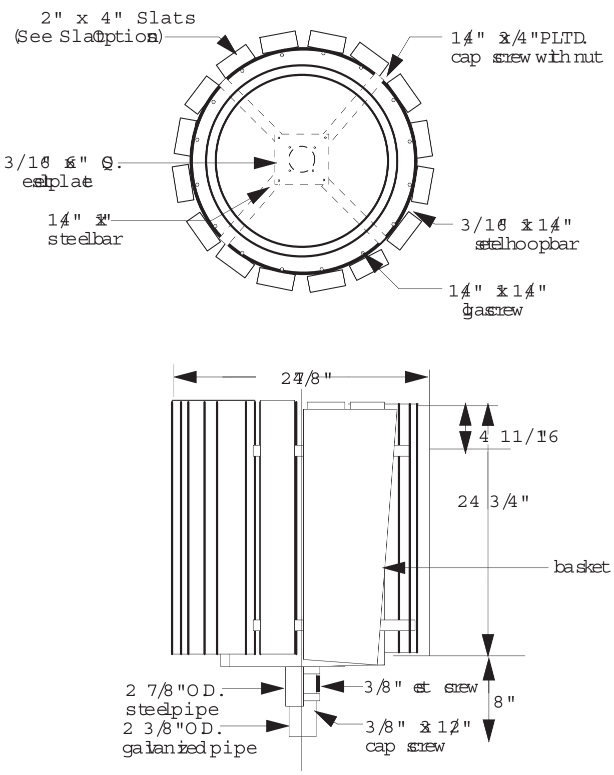


Culvert Placement Cross Section



Trash Receptacles

Trash containers can be attractive as well as functional and should be selected based on the amount of trash expected, the overall maintenance program of the trail, and the types of expected users. Trash cans need to be accessible to both trail users and maintenance personnel. At a minimum, 22-gallon or 32-gallon containers should be located at each entranceway and at each bench seating area. They should be set back 3' from the edge of the trail.

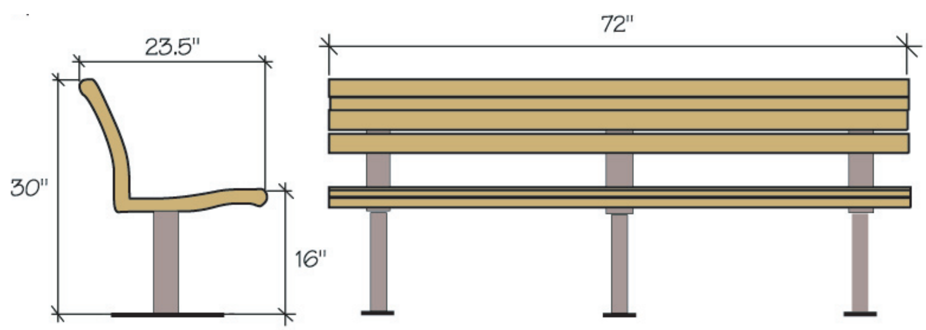


Typical Trash Receptacle Detail

Benches

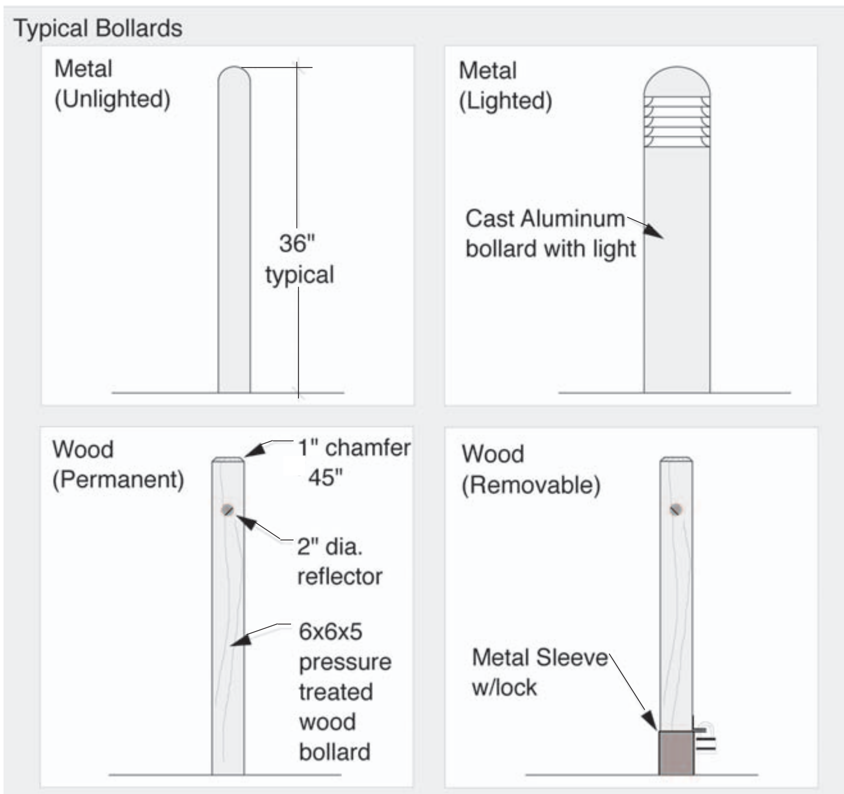
Benches along trails allow users to rest, congregate or contemplate. Trail benches should comfortably accommodate the average adult. They should be located at the primary and secondary entrances to the trail and at regular intervals, and should be set back 3' from the trail edge.

The graphics below illustrate a bench that can be manufactured using recycled plastic lumber or conventional treated wood lumber. The prefabricated plastic lumber units cost more initially but can save money over the long-term in maintenance and replacement costs.

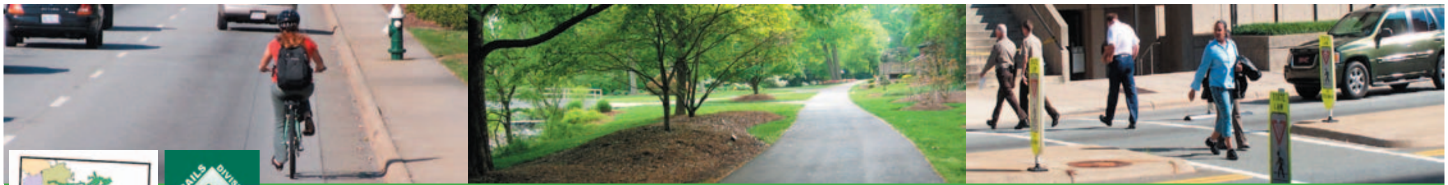


Bollards

Bollards are intended to provide separation between vehicles and trail users. They are available in a variety of shapes, sizes, and colors and come with a variety of features. Lighted bollards are intended to provide visitors with minimum levels of safety and security along trails which are open after dark. Bollards should be chosen according to the specific needs of the site and should be similar in style to the surrounding elements. Typical construction materials for bollards include painted steel or aluminum, with halogen or metal halide lights in weather tight casings. Removable bollards can be installed to provide trail access for emergency and maintenance vehicles.

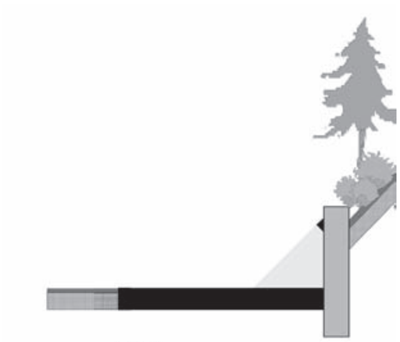


Typical Bollard Details



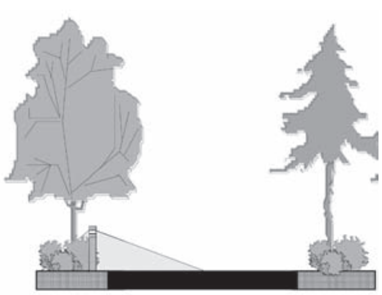
Trail Lighting

Particularly during winter months when trips to and from work are made in the dark, adequate lighting can make the difference in a person's choice to bicycle or walk. Lighting for multi-use trails should be considered on a case-by-case basis in areas where 24-hour activity is expected, with full consideration of the maintenance commitment lighting requires. Poorly maintained lights can lead to a number of serious safety issues. If lights are installed, they MUST be well maintained.

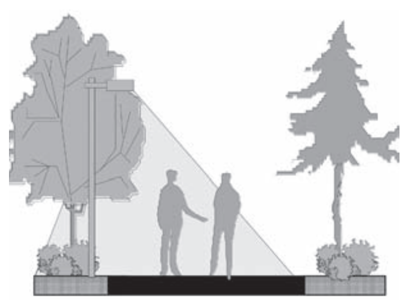


Wall

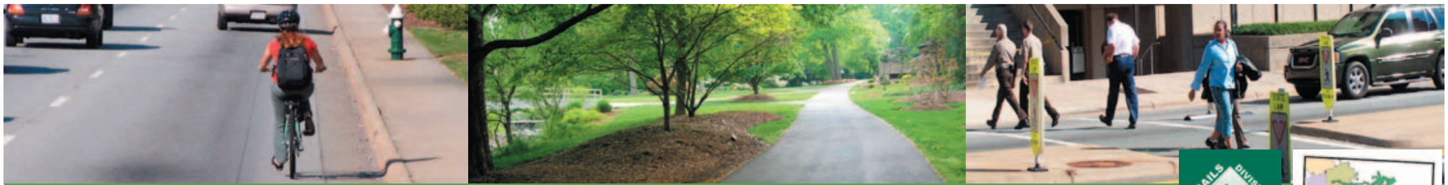
Up Lighting



Path



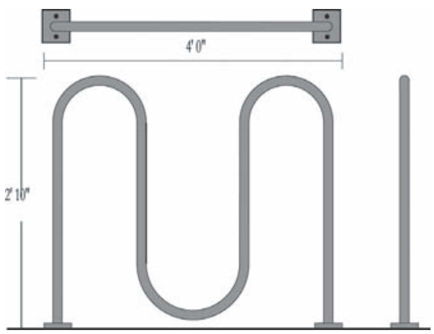
Spot Lighting



Bike Rack

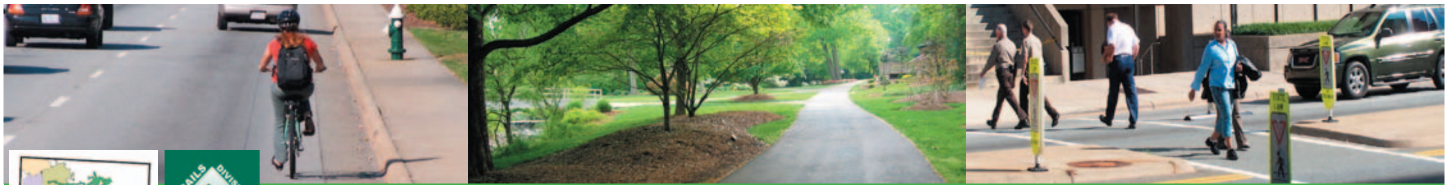
It is important to choose a bicycle rack design that is simple for cyclists to operate. Bicycle racks should be designed to allow use of a variety of lock types. It may be difficult initially to determine the number of bicycle parking spaces needed. Therefore, bike racks should be situated on-site so that more can be added if bicycle usage increases.

The design shown below has proven popular and effective in numerous communities. It is inexpensive to fabricate locally, easy to install, vandal resistant and works well with popular high-security locks. In addition, it can be installed as a single unit, on a sidewalk, or in quantity, at major recreation nodes.



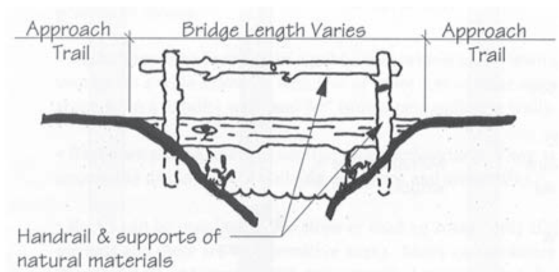
<u>Location Criteria:</u>

- Racks should be located within 50' of building entrances (where bicyclists would naturally transition into pedestrian mode).
- Racks should be installed in a public area within easy viewing distance from a main pedestrian walkway, usually on a wide sidewalk with five or more feet of clear sidewalk space remaining (a minimum of 24" clear space from a parallel wall and 30" from a perpendicular wall).
- Racks are placed to avoid conflicts with pedestrians. They are usually installed near the curb and at a reasonable distance from the building entrances and crosswalks.
- Racks can be installed at bus stops or at loading zones (only if they do not interfere with boarding or loading patterns and there are no alternatives). Bike racks on busses also facilitate bike-on-transit travel.

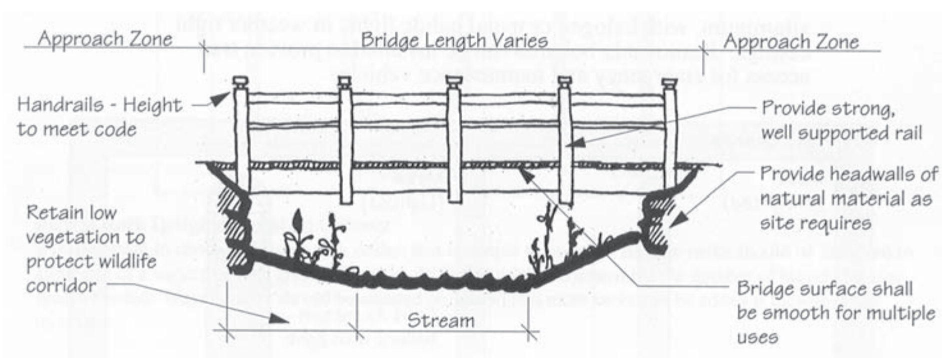


Bridges

Bridges are an important element of almost any trail project. The type and size of bridges can vary widely depending on the trail type and specific site requirements. Some bridges often used for multi-use trails include suspension bridges, prefabricated span bridges and simple log bridges. When determining a bridge design for multi-use trails, it is important to consider emergency and maintenance vehicle access. Bridges intended for occasional vehicular use must be designed to handle up to 10,000 pound loads safely and be at least 14' wide to allow for vehicle passage.



Foot Bridge



Urban Trail Bridge

Span Bridge

This bridge crosses the Tar River in Rocky Mount, NC

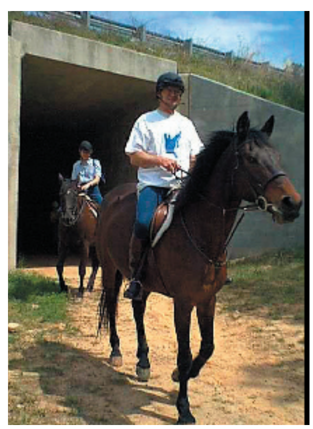
Note: Prefabricated span bridges are ordered directly from the manufacturer. Approximate cost is $100/foot.

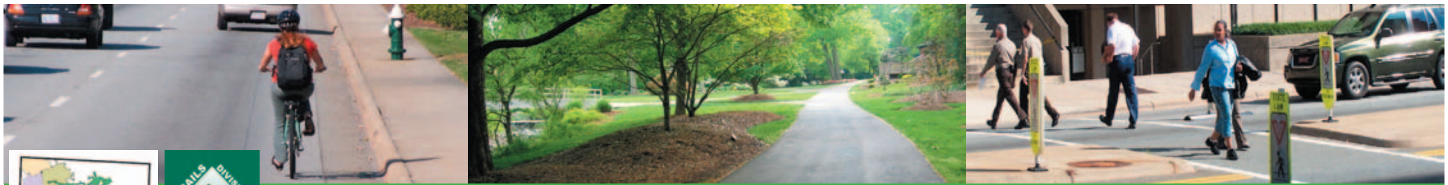
Underpass

Trail underpasses and overpasses can be used to avoid undesirable at-grade intersections of trails and freeways or high volume arterial highways. However, they should be used sparingly in suburban, fringe or rural areas. Underpasses typically utilize existing overhead roadway bridges adjacent to a stream or culverts under the roadway that are large enough to accommodate trail users. There are several key issues that must be addressed in the design of the roadway underpass:

1. The vertical clearance of the underpass must be at least 10 feet
2. The width of the underpass must be at least 12 feet
3. Proper drainage must be established to avoid pooling of stormwater inside the underpass
4. It is recommended that underpasses be lighted for safety



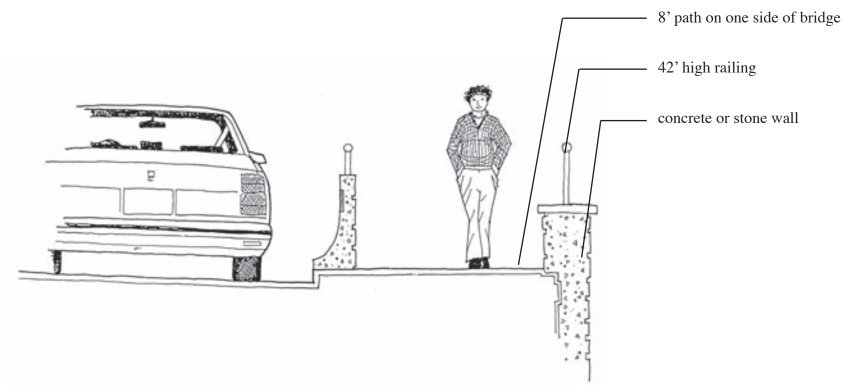





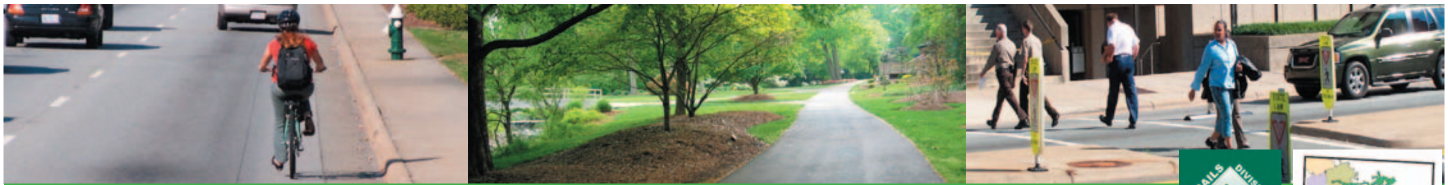
Overpass

Trail overpasses can be used in high traffic volume areas where underpasses are not possible. Overpass options include sidewalks on bridges, freestanding pedestrian/bike bridges or lanes attached to an existing bridge. The American Association of State Highway Transportation Officials (AASHTO) requires that bridges be a minimum of 36" wide, but prefers that they are at least as wide as the trail. Railing is required to be 42" high. A fenced cover, as shown below, provides a safer environment over highways and busy streets. The NCDOT should be referenced for height requirements, which vary depending on the type of road. Ramp specification should meet ADA requirements.

It is important to remember that pedestrians and cyclists will opt not to use an overpass or an underpass if it takes more than twice the time as crossing the street at-grade. For this reason, at-grade fencing might be a better alternative in some instances.

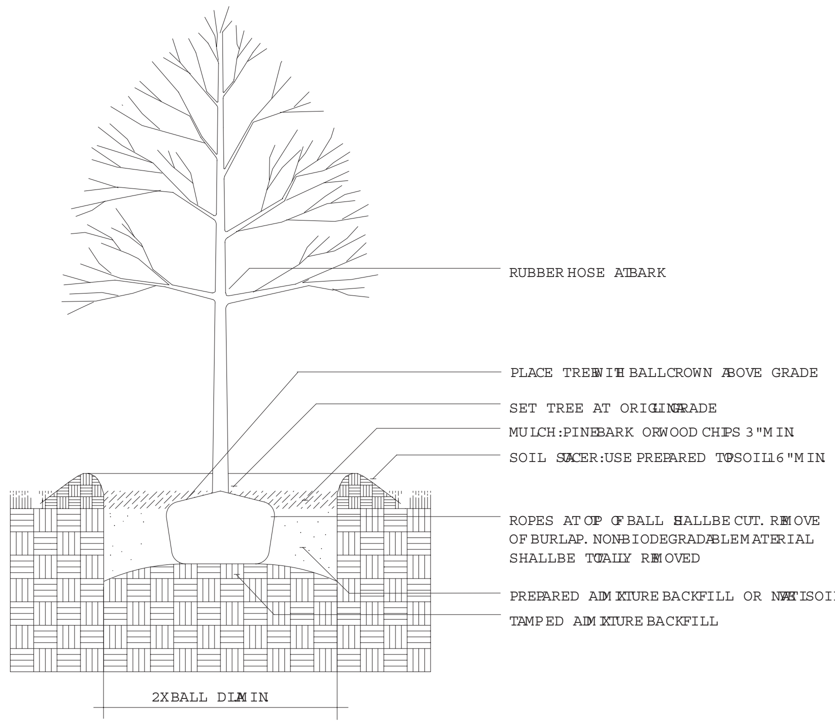


Typical Roadway Bridge with Sidewalk

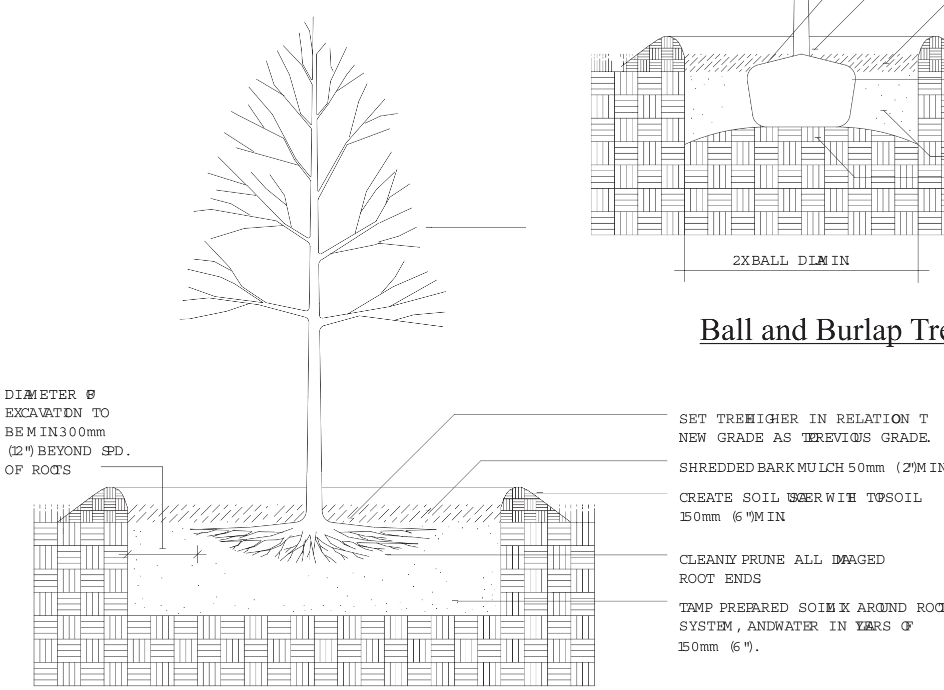


Tree Plantings

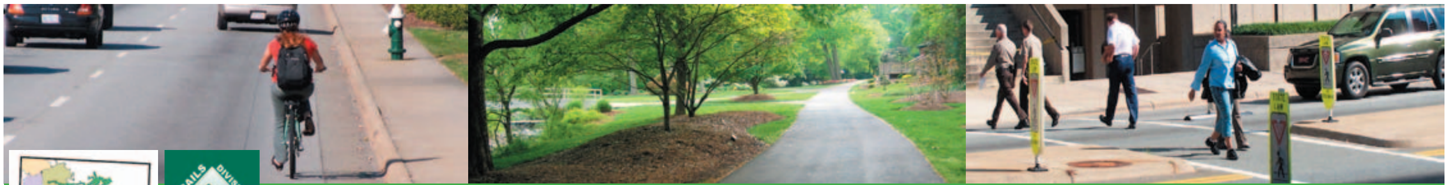
Trees are important to greenways and trails for both aesthetic and environmental reasons. Not only do they contribute to the appearance of a trail, their shade cools the environment for trail users and provides habitat for birds and wildlife. Trees also help keep streams healthy by providing shade (which regulates the temperature), filtering pollutants in storm runoff and adding leaf litter to feed small insects and fish. When choosing trees and shrubs for greenway corridors, it is recommended that indigenous and well-adapted species be used. This will reduce the need for chemical and water applications as a part of long term maintenance. The following graphics represent common installation practices used for several different types of plant material.



Ball and Burlap Tree Planting Detail

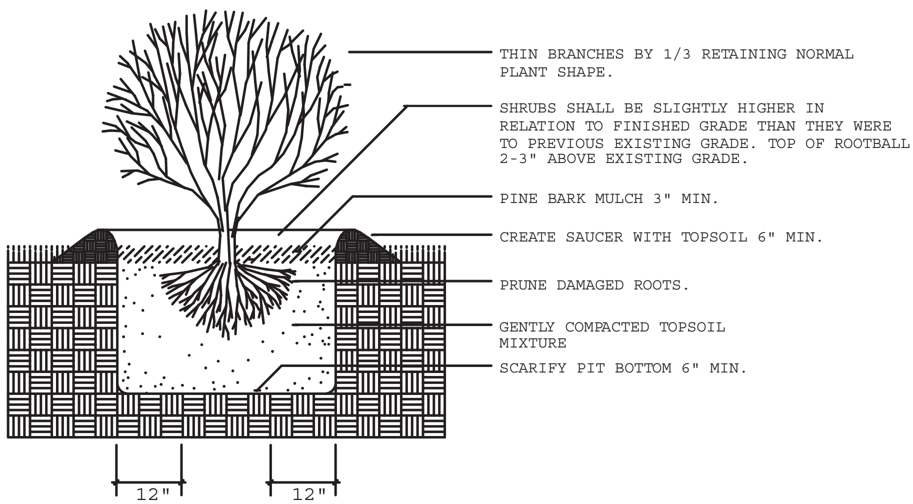


Bare Root Tree Planting Detail

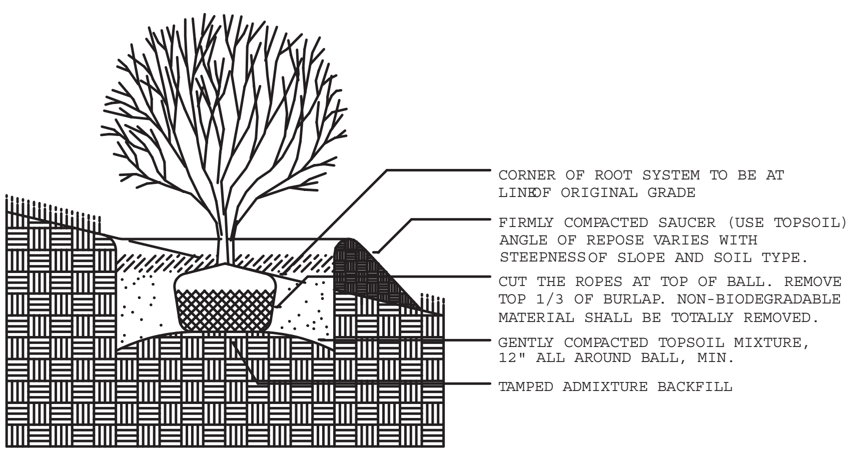


Shrub Plantings

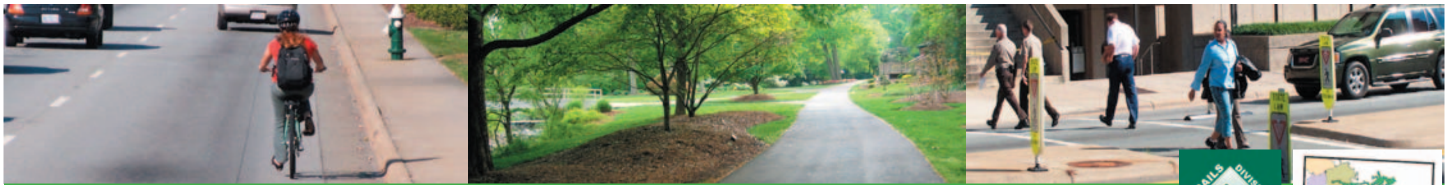
The amount of planting needed will vary depending on the project. While some projects will require little or no planting, others may require it for vegetative screening, habitat restoration, erosion control or aesthetics. The graphics below illustrate planting techniques for two types of shrub material (ball & burlap and bare root).



Bare Root Shrub Planting Detail



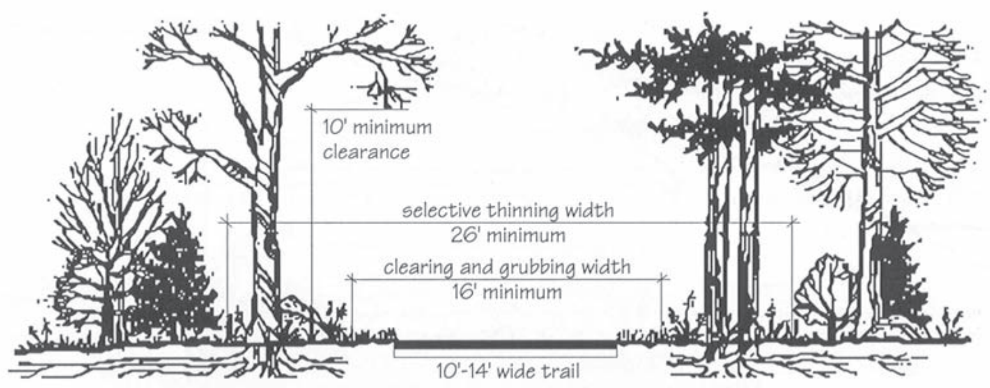
Ball and Burlap Shrub Planting Detail



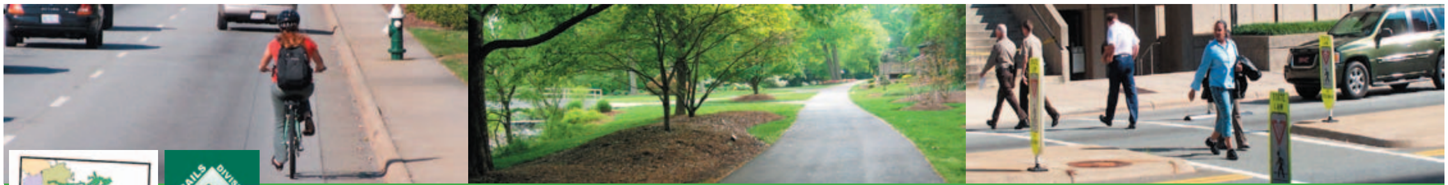
Vegetative Clearing

Vegetative clearing refers to the amount of vegetation removal that is required for various levels of trail development. The amount of vegetative clearing required for any one trail will depend on the type of trail being developed. While footpaths or hiking trails require little or no vegetation removal, paved pathways may require significantly more.

Single-tread, multi-use trails are the most common trail type in the nation. These trails vary in width, can accommodate a wide variety of users and are especially popular in urban areas. While the vegetative clearing needed for these trails varies with the width of the trail, the graphic below outlines typical requirements. The minimum width for clearing and grubbing a 14' wide trail is 16'. Selective thinning increases sight lines and distances and enhances the safety of the trail user. This practice includes removal of underbrush and limbs to create open pockets within a forest canopy, but does not include the removal of the forest canopy itself.



Typical Tree Trimming Distances



C2. Sidewalk Considerations

Sidewalks are a critical component of this Plan, especially related to the pedestrian portion. They not only encourage walking, but they also improve the safety of pedestrians. An individual's decision to walk is as much a factor of convenience as it is the perceived quality of the experience. Pedestrian facilities should be designed with the following factors in mind:

<u>Sufficient width</u>
Sidewalks should accommodate anticipated volumes based on adjacent land uses, and should at a minimum allow for two adults to walk abreast (min. 5', prefer 6').

<u>Protection from traffic</u>
High volume and/or high speed (greater than 35 mph) motor vehicle traffic creates dangerous and uncomfortable conditions for pedestrians. Physical (and perceptual) separation can be achieved through a combination of methods: a grassy planting strip with trees, a raised planter, bicycle lanes, on-street parallel parking, etc.

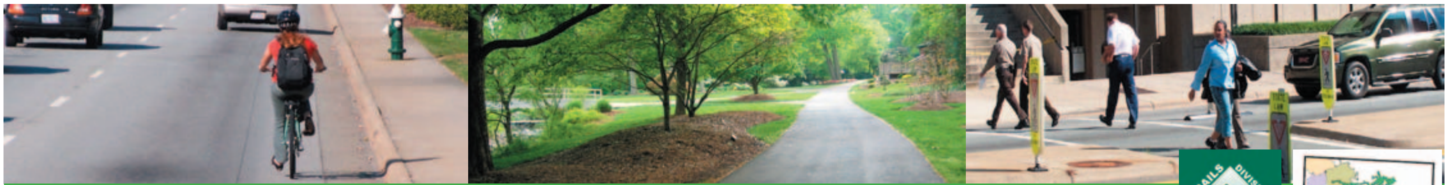
<u>Street trees</u>
Street trees are an essential element in a high quality pedestrian environment. Not only do they provide shade, they also give a sense of enclosure to the sidewalk environment which enhances the pedestrian's sense of a protected environment.

<u>Pedestrian-scaled design</u>
Large highway-scale signage reinforces the general notion that pedestrians are out of place. Signage should be designed to be seen by the pedestrian. Street lighting should likewise be scaled to the level of the pedestrian (14' tall), rather than providing light poles that are more appropriate on high-speed freeways.

<u>Continuity</u>
Pedestrian facilities are often discontinuous, particularly when private developers are not encouraged to link on-site pedestrian facilities to adjacent developments and nearby sidewalks or street corners. New development should be designed to encourage pedestrian access from nearby streets. Existing gaps in the system should be placed on a prioritized list for new sidewalk construction.

<u>Clearances</u>
Vertical clearance above sidewalks for landscaping, trees, signs and similar obstructions should be at least 10'. In commercial areas and the downtown, the vertical clearance for awnings should be 10'. The vertical clearance for building overhangs which cover the majority of the sidewalk should be 12'.

<u>Conformance with national standards</u>
Sidewalk design should be consistent with Americans with Disabilities Act requirements and/or ANSI requirements. Specific guidance is provided by the Architectural and Transportation Barriers Compliance Board's American's with Disabilities Act Accessibility Guidelines.



Sidewalk Obstacles

Street furniture and utility poles create obstacles to pedestrian travel when located directly on the sidewalk. At a minimum, there should be 36" of sidewalk width to allow wheelchairs to pass. Where possible, utilities should be relocated so as not to block the sidewalk. Benches should not be sited directly on the sidewalk, but set back at least 3'. The design of new intersections or re-design of existing intersections presents an opportunity to improve pedestrian circulation. Street furniture located near intersections can block sight lines. In general, the designer should consider the impact on sight distance for all features located in the vicinity of roadway intersections.

Sidewalk pavement design

Sidewalks and roadside pathways should be constructed of a solid, debris-free surface. Regardless of the type of surface chosen, it must be designed to withstand adequate load requirements. Pavement depth should reflect site specific soil conditions but never be less than 4.5." Brick and concrete pavers are popular materials for more decorative sidewalks. The use of stylized surfaces is encouraged, however they must be installed properly or they will deteriorate more rapidly.

Sidewalk width and setback guidelines

It is important to note that there are some areas that warrant wider sidewalks. For example, sidewalks in and around local universities and colleges must accommodate a much higher volume of pedestrians and, therefore, warrant additional width. The recommendations below are based upon standards used by other pedestrian-friendly communities in the U.S. Following the recommendations below ensures that basic needs of pedestrians are addressed in developing areas. In existing residential and commercial areas that lack sidewalks, new sidewalk construction (independent of new development) should occur first in locations that demonstrate the most need.

Sidewalks on local streets in residential areas

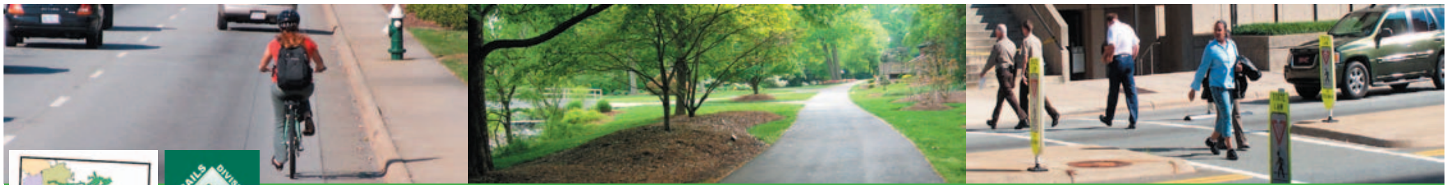
Five-foot wide sidewalks are recommended on at least one side of the street, with a 5 feet wide planting strip. The planting strip may need to be slightly wider to accommodate the roots of street trees, if they are included in the design. Sidewalks are not necessary on cul-de-sacs that are less than 500 feet in length.

Sidewalks on collector streets in residential and commercial areas

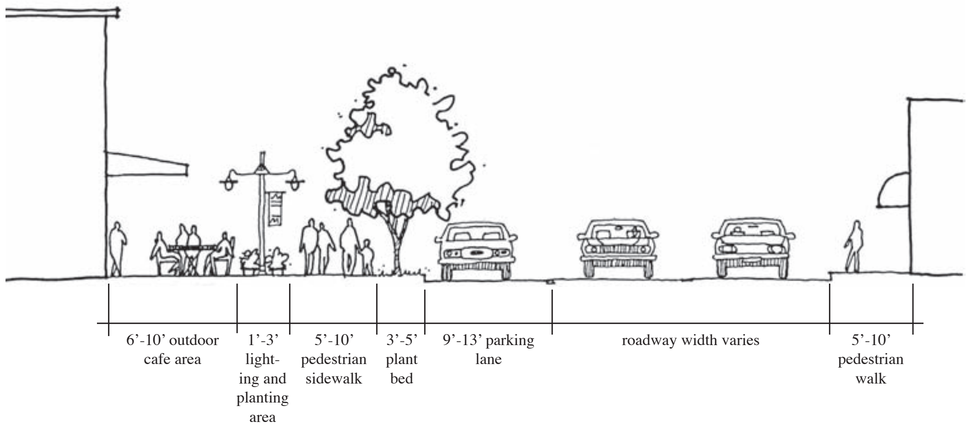
Five-foot wide sidewalks are recommended on both sides of the street. However, one option may be to install a 6 feet wide sidewalk on the side of the street that generates the most activity. A 7 foot wide planting strip is recommended.

Sidewalks on arterial streets in residential and commercial areas

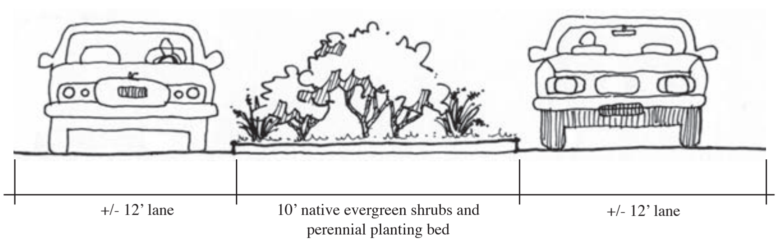
Six foot sidewalks are recommended on both sides of the street, with an 8' wide planting strip.



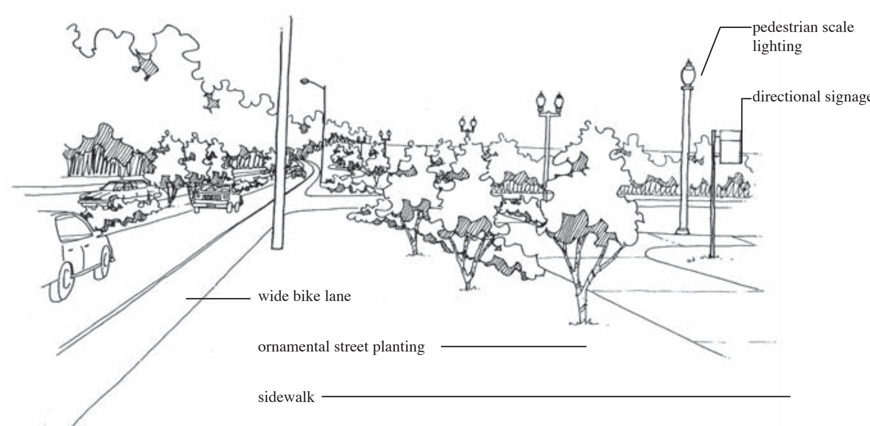
Roadside Treatments



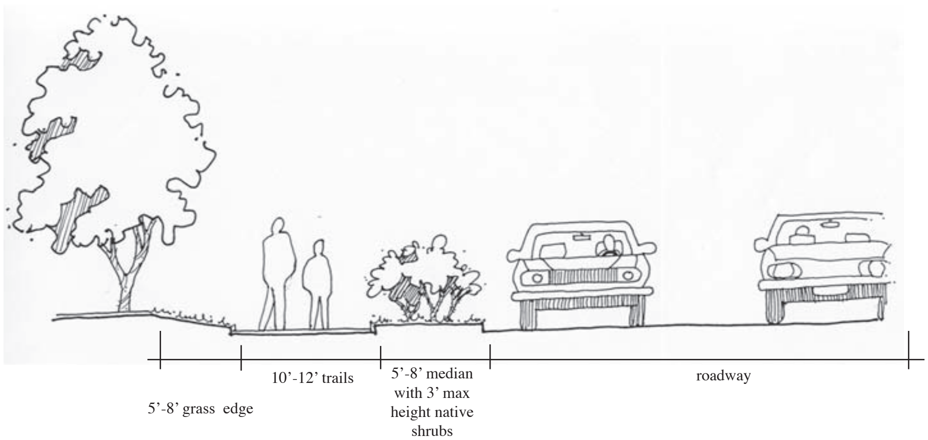
Typical Street Section



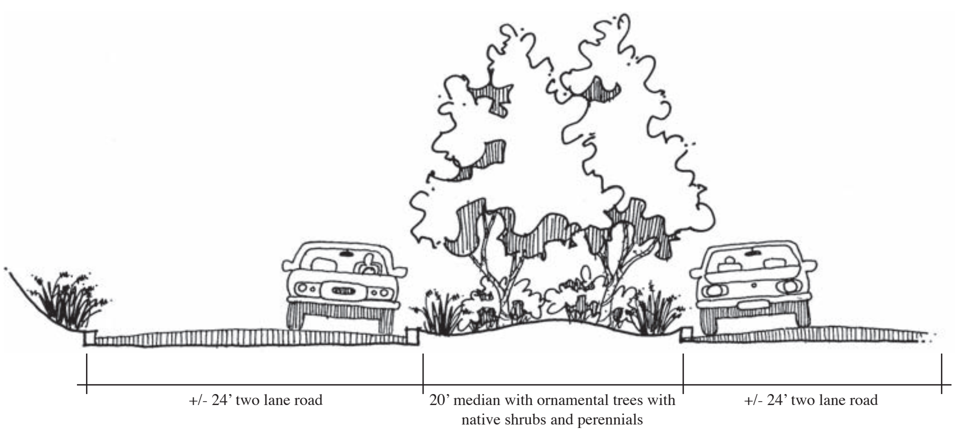
Typical Median Shrub Planting



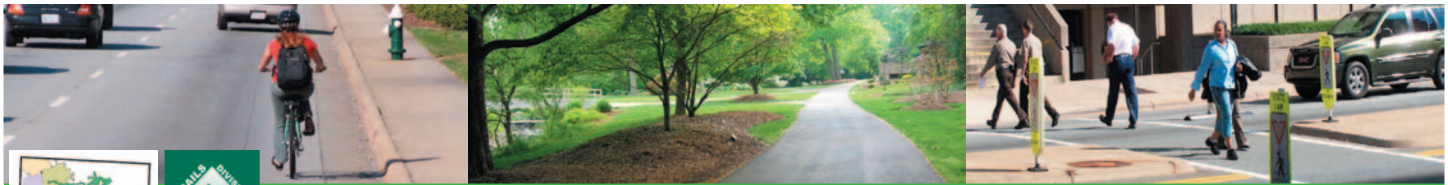
Typical Scenic Road Corridor



Typical Road with Adjacent Sidewalk



Typical Median Planting



C3. Pedestrian and Bicycle Facility Design Guidance

This section describes the reasoning behind several important pedestrian and bicycle facility design concepts in the Plan. While this part of the appendix does not represent a complete set of pedestrian and bicycle design guidelines, it can be referenced by planners, engineers, and designers looking to provide new and retrofit existing pedestrian and bicycle facilities in the Greensboro Urban Area.

Sidewalks on Both Sides of Roadways
Sidewalks should be provided on both sides of all collector, subcollector, and local streets (with the exception of short cul-de-sacs or dead-end streets, and roadways in areas with rural development (e.g., less than one dwelling unit per 6 acres).

Justification

All streets should have some type of walking space out of the vehicular travelway. When a sidewalk is provided on only one side of the street, pedestrians traveling on the opposite side may not cross to the sidewalk, and may instead elect to walk in the roadway. This creates an uncomfortable and potentially hazardous situation. If pedestrians do cross, they increase their exposure to vehicular traffic. Though it may be appropriate for some streets in developing areas to temporarily have a pedestrian walkway only on one side, sidewalks on both sides are necessary for pedestrian-compatible roadways. A research study of pedestrians' perceptions of walking along different types of roadway segments found that sidewalk presence has a significant positive effect on pedestrians' feelings of safety and security while walking along roadways (1). Further, an analysis of 47 pedestrian crash sites and 94 comparison sites found that the absence of sidewalks was associated with a significantly higher likelihood of pedestrian crashes (2).

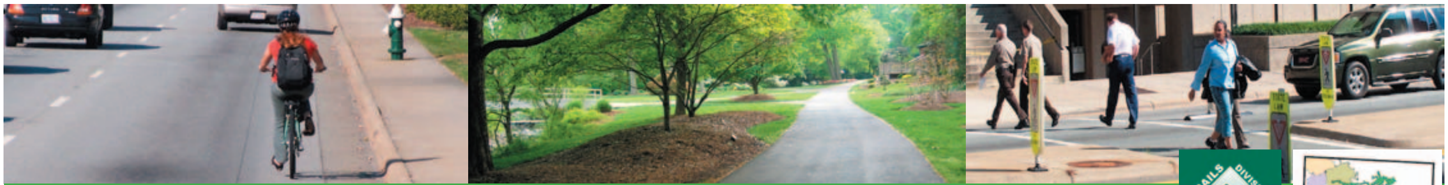
Decisions on whether to provide a sidewalk should not be based on existing pedestrian volumes because they are not a reliable indication of pedestrian demand. Individuals tend to walk more in locations where continuous connections are provided. A lack of pedestrian activity in a location with discontinuous sidewalks is not necessarily an indication of a lack of pedestrian demand.

1. Landis, B.W., V.R. Vattikuti, R. M. Ottenberg, D.S. McLeod, M. Guttenplan. “Modeling the Roadside Walking Environment: Pedestrian Level of Service,” *Transportation Research Record 1773*, Transportation Research Board, National Academy of Sciences, 2001.

2. McMahon, P.J., C.V. Zegeer, C. Duncan, R.L. Knoblauch, J.R. Stewart, and A.J. Khattak. *An Analysis of Factors Contributing to “Walking Along Roadway” Crashes: Research Study and Guidelines for Sidewalks and Walkways*, Federal Highway Administration, FHWA-RD-01-101, February 2002.

Minimum Sidewalk Width
Sidewalks should have a minimum width of five feet.

Justification



A five-foot sidewalk width is very important, as it enables two people to walk side by side, which is not possible on 4-foot wide sidewalks. Many other jurisdictions have increased their minimum sidewalk width to 5 feet. In addition, new rules that will be issued by the U.S. Access Board in the near future will require that 4-foot sidewalks provide a 5-foot passing area (a wider area where two wheelchairs can pass) every 200 feet. This makes constructing continuous 5-foot sidewalks much more practical than sidewalks of varying width. Additional sidewalk width is particularly important for locations with higher volumes of pedestrian activity, such as near schools, shopping centers, parks, and other pedestrian attractors. In these locations, it would be beneficial to require sidewalks that are 6-feet wide (or wider).

Sidewalk Buffers
The buffer space between the sidewalk and the curb and gutter (or edge of pavement) should be maximized within the available right-of-way.

Justification

Pedestrians feel more comfortable when there is a greater buffer between the sidewalk and the street, particularly when the roadway serves high volumes of traffic. A scientific study of the real-time perceptions of pedestrians walking along roadway segments identified buffer width as a significant factor in a pedestrian's comfort level. The study also showed that on-street parking and street trees also act as buffers between roadway traffic and the sidewalk and increase pedestrian comfort (1).

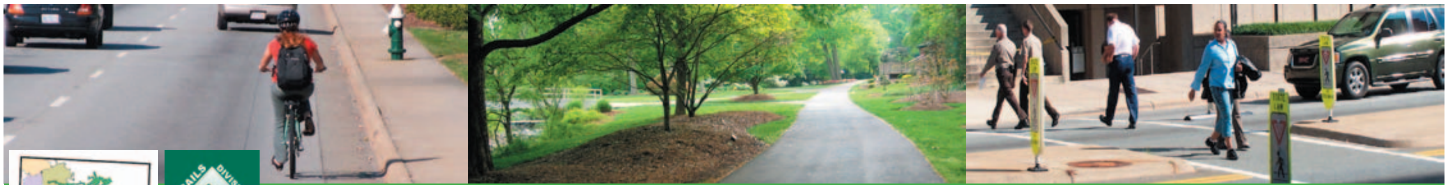
1. Landis, B.W., V.R. Vattikuti, R. M. Ottenberg, D.S. McLeod, M. Guttenplan. "Modeling the Roadside Walking Environment: Pedestrian Level of Service," *Transportation Research Record 1773*, Transportation Research Board, National Academy of Sciences, 2001.

Raised Median Islands
Raised medians or pedestrian refuge islands should be provided, where practical, at crosswalks on streets with more than three lanes, especially on streets with high volumes of traffic. Median widths of 6 to 10 feet are recommended. Medians should be made accessible through the provision of level cut-throughs or curb ramps.

Justification

Raised medians have been shown to significantly reduce the incidence of pedestrian crashes, particularly at multi-lane sites. Medians make it easier for pedestrians to cross the street by reducing the width of roadway that pedestrians must cross at one time. Raised medians may provide a place for landscaping and change the character of the street, possibly reducing the speeds of vehicles. Medians and channelizing islands also reduce the rate of motor vehicle crashes and have particular benefits for older drivers.

Research suggests that raised medians are more effective than painted medians at reducing pedestrian crashes. Zegeer et al. found that raised medians and crossing islands correspond with a significantly lower crash rate on multi-lane roads with both marked and unmarked crosswalks, but that painted medians did not correspond with a reduction in pedestrian crash rates compared with multi-lane roads without medians (1).



Bowman and Vecellio also found that locations with raised medians correspond with lower pedestrian crash frequencies compared to locations on undivided arterial streets (2). Research in Australia described by Peter Cairney found that locations with raised medians had lower pedestrian crash frequencies than locations without, but that narrow medians have higher crash frequencies than wider ones (3).

1. Zegeer, C., Stewart J., Huang, H. and Lagerwey, P. "Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations- Executive Summary and Recommended Guidelines." Report No. FWHA-RD-01-075, Federal Highway Administration, Washington, DC, March 2002.

2. Bowman, B.L., and R.L. Vecellio. "Effect of Urban and Suburban Median Types on Both Vehicular and Pedestrian Safety. " *Transportation Research Record* 1445 (1994): 169-179.

3. Cairney, Peter. "Pedestrian Safety in Australia." FHWA-RD-99-093. Federal Highway Administration, Washington DC, December 1999.

In-Street Pedestrian Crossing Signs

In-Street Pedestrian crossing signs (*MUTCD* sign R1-6) may be placed in the roadway at crosswalks to remind motorists of their responsibility to yield to pedestrians within the crosswalk. The *MUTCD* specifies that these signs may not be used at signalized locations.

Justification

In-street pedestrian crossing signs often increase the incidence of drivers yielding to pedestrians in the crosswalk by reminding motorists that it is their legal responsibility (1, 2, and 3).

1. City of Madison, Wisconsin Department of Transportation, Traffic Engineering Division, "Year 2 Field Evaluation of Experimental 'In-Street' Yield to Pedestrian Signs," Submitted to FHWA 1999.

2. H.F. Huang, C.V. Zegeer, R. Nassi, and B. Fairfax. "The Effects of Innovative Pedestrian Signs at Unsignalized Locations: A Tale of Three Treatments," FHWA, FHWA-RD-00-098, 2001, available online at: www.tfhrc.gov/safety/pedbike/pubs/00-098.pdf

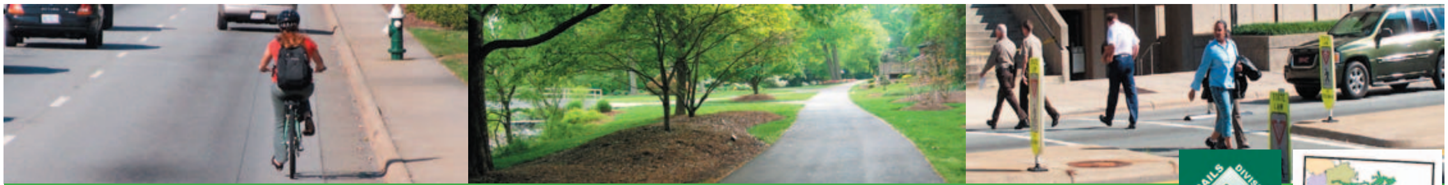
3. Ercolano, J. "Pedestrian Crossing Devices," Case Study #28 in *PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System,* FHWA, FHWA-SA-04-003, September 2004.

Leading Pedestrian Interval (LPI)—Pedestrian Signal Timing

At signalized intersections with high pedestrian crossing volumes, the signals can be programmed to allow pedestrians to begin crossing 2 to 4 seconds before the vehicle traffic on the parallel street is given a green light.

Justification

This is a low-cost treatment. It gives pedestrians enough time to cross to the middle of the street so that turning



vehicles can see them, be aware of them, and yield to them before they receive a green light. Because the LPI is operated by the traffic signal controller, it is also possible to use the LPI only during certain times of the day, such as between 7 a.m. and 7 p.m., whenever the highest numbers of pedestrians are typically present. A study of a three-second leading pedestrian interval (LPI) found that the LPI decreased conflicts between turning motor vehicles and increased the percentage of motorists that yielded to pedestrians in the crosswalk (1).

Traffic signals with LPI have a longer all red phase, which may tempt drivers to take advantage of the extra time and run red lights. This type of behavior should be prevented through education and strict enforcement (2).

1. Van Houten, R., R. A. Retting, C. M. Farmer, J. Van Houten, and J. E. L. Malenfant. "Field Evaluation of a Leading Pedestrian Interval Signal Phase at Three Urban Intersections," Transportation Research Record 1734, 2000.
2. Zegeer, C.V., Seiderman, C., Lagerwey, P., Cynecki, M., Ronkin, M. and Schneider, R. Pedestrian Facilities Users Guide: Providing Safety and Mobility, Federal Highway Administration, FHWA-RD-01-102, March 2002.

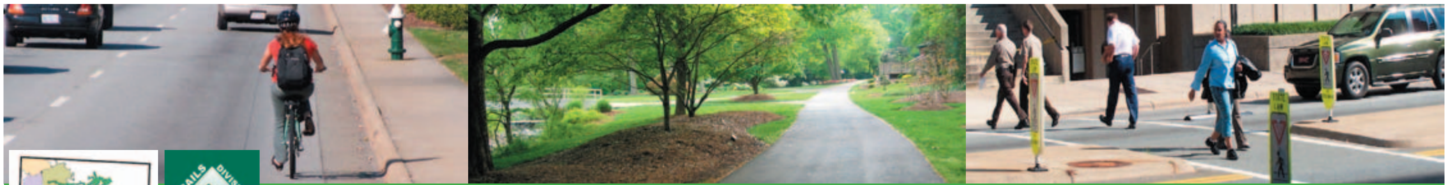
Traffic Calming

Traffic calming is the practice of slowing traffic speeds by reducing the design speed of roadways. This is done by making various physical changes to the roadway, including adding raised median islands, curb extensions, and raised crosswalks; adding chicanes; narrowing travel lanes; etc. Traffic calming is appropriate on neighborhood streets that should have low traffic speeds.

Justification

Numerous studies have shown that traffic calming has many benefits, including reductions in the number and severity of collisions, reductions in vehicular speeds, reductions in noise levels, and improvements in the comfort of pedestrians and bicycles (1, 2, 3, and 4). Since traffic speed is correlated with the severity of pedestrian crashes, the reduction of speeds help improve pedestrian safety. It is estimated that 85% of pedestrians who are struck at 40 mph are killed, 45% at 30 mph, and only 5% at 20 mph (5).

1. Institute of Transportation Engineers, Traffic Calming: State of the Practice, August 1999.
2. Zegeer, C.V., J.Stuart, and H. Huang, Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Crossing Locations, Federal Highway Administration, Washington, DC, 1999.
3. City of Cambridge, MA, Preliminary Results: Effects of Columbia Street Traffic Calming Project on Driver Behavior, April 2000.
4. Zein, S.R., Geddes, E., Memsing, S., Johnson, M., "Safety Benefits of Traffic Calming," Transportation Research Record, Volume 1578 pp. 3-10, 1997.
5. Ashton, S.J. and Mackay, G.M., "Some characteristics of the population who suffer trauma as pedestrians when hit by cars." Proceedings of the 4th International IRCOBI Conference on the Biomechanics of Truma, Goeteborg, Sweden, 5-7 September, 1979.



Travel Lane Widths
Roadway travel lane widths should not be excessively wide. Local and collector roadways should generally be striped with 10-foot travel lanes. Arterial roadways should have 10- or 11-foot lanes, depending on traffic volume and use by heavy trucks.

Justification

According to AASHTO's *Guide for Achieving Flexibility in Highway Design* (2004), the normal range of design lane width is between 9 and 12 feet (1). This guide states:

"In urban areas and along rural routes that pass through urban settings, narrower lane widths may be appropriate. For such locations, space is limited and lower speeds may be desired. Narrower lane widths for urban streets lessen pedestrian crossing distances, enable the provision for on-street parking and transit stops, and enable the development of left-turn lanes for safety."

Narrowing existing travel lanes can provide extra space for shoulders and bicycle lanes. In some situations this may also have a desired traffic calming effect, slowing typical motor vehicle traffic by several miles per hour.

According to the AASHTO *Policy On Geometric Design of Highways and Streets* (2004), minor thoroughfares (collector roadways) can be designed with 10-foot motor vehicle travel lanes. Ten-foot travel lanes are already used on several roadways in the Greensboro Metropolitan Area. Wider widths should be considered in rural areas if the roadway has high traffic volumes or speeds and considered in urban areas if the roadway carries a large amount of truck traffic (p. 425, 433).

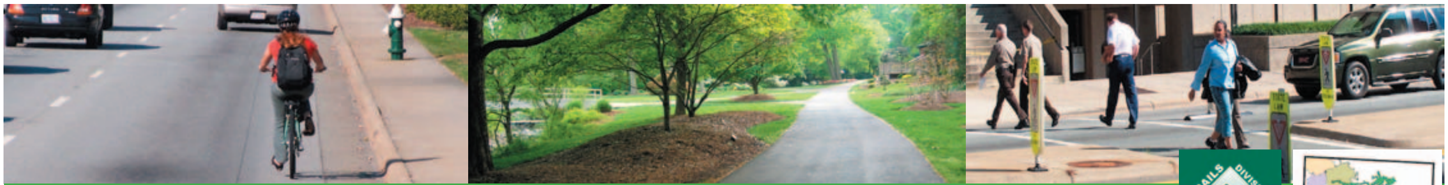
Major thoroughfares (arterial roadways) are commonly designed with 11-foot travel lanes. However, in urban areas, some major thoroughfares can have narrower lanes. The AASHTO guide states, "Lane widths of 3.0 m [10 ft] may be used in highly restricted areas having little or no truck traffic" (p. 472) (2).

1. American Association of State Highway Transportation Officials. *A Guide for Achieving Flexibility in Highway Design*, 2004. Order from: https://bookstore.transportation.org/publications/bookstore.nsf/Categorized?OpenForm&cat=Design/Operations/Planning
2. American Association of State Highway Transportation Officials. *Policy On Geometric Design of Highways and Streets, Fifth Edition*, 2004. Order from: https://bookstore.transportation.org/publications/bookstore.nsf/Categorized?OpenForm&cat=Design/Operations/Planning

Bicycle Lanes
Bicycle lanes should be provided, where practical, on collector and arterial roadways in Greensboro.

Justification

National research has shown that bicyclists feel more comfortable and motor vehicles give bicyclists more lateral space when a shoulder or bike lane stripe is provided (Landis, et al. 1996; Harkey, et al. 1998; Hunter, et al. 1999; City of Cambridge, MA 2005) (1,2,3,4). Bike lanes help bicyclists navigate through complex



intersections with turn lanes and other features that might otherwise deter bicyclists. This research is supported by policies in the AASHTO Bicycle Guide (1999)(5), which states:

"Bike lanes are intended to delineate the right of way assigned to bicyclists and motorists and to provide for more predictable movements by each. Bike lanes also help to increase the total capacities of highways carrying mixed bicycle and motor vehicle traffic…[Bike lanes may be provided] by reducing the width of vehicular lanes or prohibiting parking…" (p. 8)

1. Landis, Bruce W.; Venkat R. Vattikuti; and Michael T. Brannick. "Real-Time Human Perceptions: Towards a Bicycle Level of Service," *Transportation Research Record 1578*, 1996. Available Online: http://www.dot.state.fl.us/planning/systems/sm/los/pdfs/BLOS_TRBscanned.pdf
2. Harkey, D.L.; D.W. Reinfurt; M. Knuiman; and A. Sorton. *Development of the Bicycle Compatibility Index: A Level of Service Concept: Final Report*, Report No. FHWA-RD-98-072, Federal Highway Administration, Washington, DC, August 1998. Available Online: http://www.hsrc.unc.edu/research/pedbike/98095/.
3. Hunter, William W.; J. Richard Stewart; Jane C. Stutts; Herman H. Huang; and Wayne E. Pein. *A Comparitave Analysis of Bicycle Lanes Versus Wide Curb Lanes: Final Report*, Federal Highway Administration, FHWA-RD-99-034, December 1999. Available Online: http://www.walkinginfo.org/pdf/r&d/widelanes_final.pdf.
4. City of Cambridge, MA. "Safety Benefits of Bike Lanes." Available Online: http://www.cambridgema.gov/~CDD/et/bike/bike_safety.html.
5. American Association of State Highway and Transportation Officials. *Guide for the Development of Bicycle Facilities*, 1999.

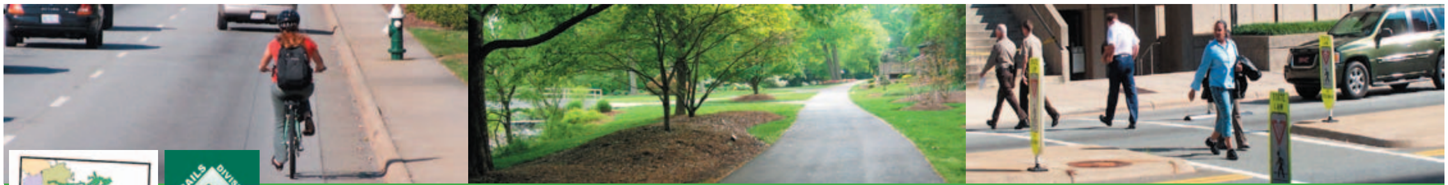
Paved Shoulders on Rural Roads

Paved shoulders should be provided on rural roadways with moderate to high traffic volumes in the Greensboro Metropolitan Area. There is no minimum width for paved shoulders, though a width of at least 4 feet is preferred. On many roadways, motor vehicle travel lanes can be narrowed to provide more shoulder space.

Justification

The benefits of paved shoulders to motor vehicle use are well-documented, including reduced numbers of certain crashes, higher capacity potentials, and reduced long-term maintenance costs. Paved shoulder space also improves the safety and comfort of bicyclists. A study of the real-time perceptions of bicyclists riding on a wide variety of roadway segments found that the width of the striped shoulder area had a significant influence on bicyclists' feeling of comfort and safety. Wider shoulders increase the comfort levels of bicyclists riding along roadway segments (1). A similar result was found in a Federal Highway Administration study that asked bicyclists to rate the suitability of different roadways for bicycling from video clips (2). Wider striped shoulders are preferred by bicyclists.

Further, according to the AASHTO Guide for the Development of Bicycle Facilities (1999), "where 4-foot widths cannot be achieved, any additional shoulder width is better than none at all" (3). AASHTO's Guide for Achieving Flexibility in Highway Design (2004) states, "Paving part or all of the shoulder…helps reduce



crash rates…and helps to facilitate use of the road by bicyclists. Shoulder paving also reduces maintenance requirements….Where a 'full width' shoulder cannot be achieved, the designer should strive to provide as wide a shoulder as possible that meets functional requirements" (p. 66) (4). Therefore, paved shoulders provide space for bicyclists and pedestrians, improve safety for motor vehicles, and prevent pavement damage to the travel lanes.

1. Landis, Bruce W. et.al. "Real-Time Human Perceptions: Toward a Bicycle Level of Service," *Transportation Research Record 1578*, Transportation Research Board, Washington, DC 1997.
2. Harkey, D.L., D.W. Reinfurt, M. Knuiman, J.R. Steward, and A. Sorton. *Development of the Bicycle Compatibility Index: A Level of Service Concept*, Federal Highway Administration, FHWA-RD-98-072, December 1998.
3. American Association of State Highway and Transportation Officials. *Guide for the Development of Bicycle Facilities*, 1999.
4. American Association of State Highway and Transportation Officials. *Guide for Achieving Flexibility in Highway Design*, 2004.

Pedestrian and Bicycle Accommodations on Roadway Bridges, Underpasses, and Interchanges
Pedestrians and bicycles should be accommodated on roadway bridges, underpasses, and interchanges in Greensboro. New bridges should be constructed with bicycle lanes and wide sidewalks. Bridge replacement projects on controlled access freeways where pedestrians and bicyclists are prohibited by law will generally *not* include facilities to accommodate bicyclists and pedestrians. In cases, however, where a bridge replacement project on a controlled access freeway impacts a non-controlled access roadway (i.e. a new overpass over an arterial roadway), the project should include the necessary access for pedestrians and bicycles on the non-limited access roadway, including such elements as: paved shoulders, sidewalks, and pedestrian/bicycle crossing improvements to associated ramps and intersections. The following text describes more specifically how bicycles and pedestrians should be accommodated on bridges under different circumstances.

Urban/Suburban Bridges (Closed Section)
On urban and suburban bridge projects, shoulder width should be based on anticipated (20 year) traffic volumes, as identified in Table C(a). In urban locations with higher volumes of pedestrians, the sidewalk width should be based on a level of service analysis, per the Highway Capacity Manual.

Table C(a).

Projected Traffic Volumes (20 Year)	Designated Shoulder width (min)	Sidewalk width (min)
<15,000 ADT	5.5'	5.5'
15,000> ADT	6.5'	7'

Urban/Suburban Bridge (Closed Section) <15,000 ADT

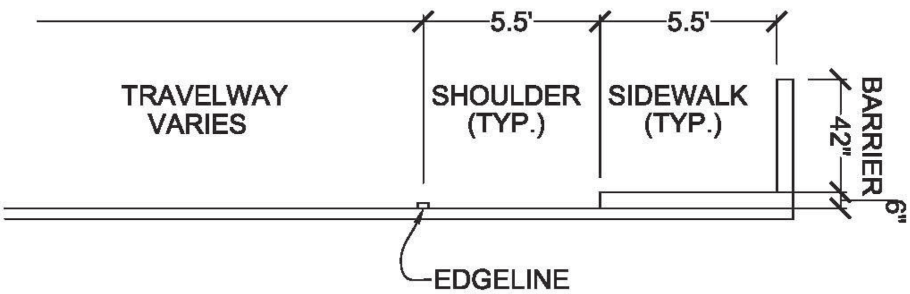


Figure C(a). Urban/Suburban Bridge <15,000 ADT

Urban/Suburban Bridge (Closed Section) >15,000 ADT

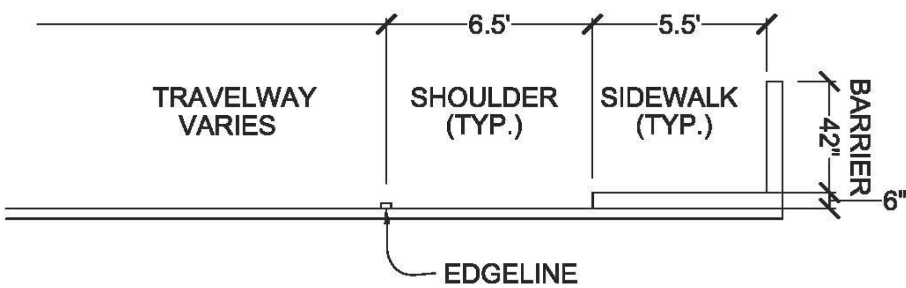
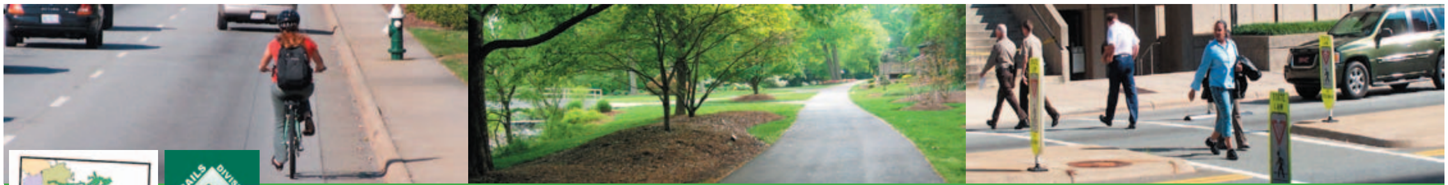


Figure C(a). Urban/Suburban Bridge >15,000 ADT

Locations with Shared Use Pathways

For bridges that have an existing or proposed shared use path approaching one side, the bridge should be constructed with a shared use path on that side, separated from traffic by a concrete barrier. Use of the concrete barrier requires a crash cushion, or should otherwise be designed so that it does not pose a hazard to errant vehicles. The pathway should be a minimum of 12' wide, and should not be less than 10' wide. The barrier between the pathway and the shoulder should be a uni-directional concrete barrier with a height of 42" from the surface of the pathway. The railing on the other side of the pathway is not required to be crashworthy. This railing should be constructed to a height of 48" from the surface of the pathway (See Figure C(c)). Transitions at the bridge approaches should enable access to the pathway on the bridge by bicyclists who may be riding on the paved shoulder rather than on the pathway.



Shared Use Path on Bridge

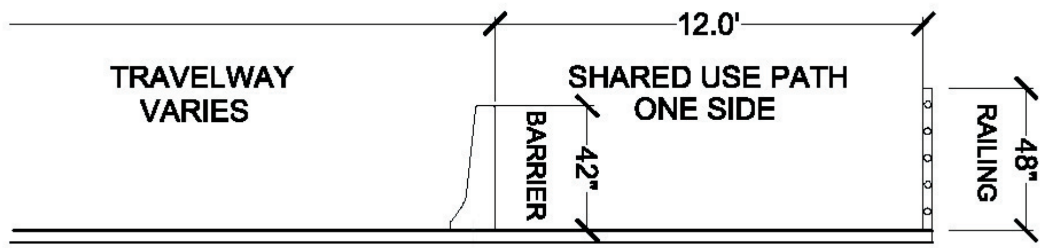


Figure C(c). Shared Use Path on Bridge

Long Bridges
Bridge replacement projects in urban or suburban areas that include one continuous bridge that is over 0.5 mile in length should include a multi-use pathway on one side of the bridge that is separated from traffic with a concrete barrier, designed according to Figure C(c). The provision of a pathway on one side requires that safe crossings (grade separated, if necessary) be provided on each end of the bridge so as to allow access to the other side of the road.

Bridges with a continuous length between.25 and .5 miles may either include a multi-use pathway on one side as defined above, or may follow the guidelines for urban/suburban bridges. The determination of the appropriate treatment should be based on the following factors:

- land uses and destinations: in an urban area with destinations in close proximity to the bridge on both sides of the road, pedestrians need access on both sides of the bridge
- cost: the cost of providing sidewalks on both sides of the bridge should be weighed against the cost of providing safe crossings (grade separated, if necessary) on either end of the bridge to enable pedestrians and bicyclists to access the other side of the road.

Rural Roads (Open Section)
The following guidelines apply to bridge replacement projects on rural roadways with open sections. These bridges should be constructed with 10' wide shoulders on both sides.

Roadway shoulder improvements associated with bridge replacement projects should include 4' wide (minimum) paved shoulders for bicycle use.

Pedestrians who occasionally use rural bridges will share the shoulder space with bicycles – sidewalks generally are not required on rural bridges. However, on bridge replacement projects that are near points of community development such as schools, shopping centers, local businesses, tourism attractions, or other land uses that result in pedestrian concentrations along the highway, a curb and sidewalk cross section should be used.

Rural Road (Shoulder Section)

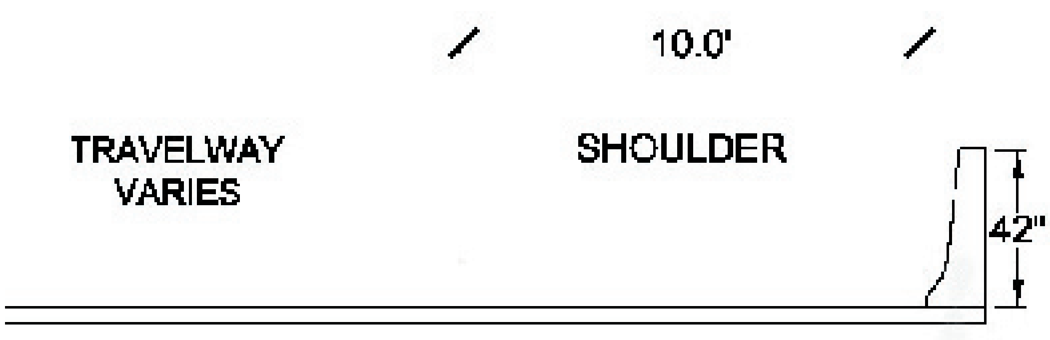


Figure C(d). Rural road (shoulder section).

Justification

The current Federal law for pedestrian and bicycle accommodation on bridges was established in the Transportation Equity Act for the 21st Century (TEA-21) and re-affirmed by the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). This law states:

"In any case where a highway bridge deck is being replaced or rehabilitated with Federal financial participation, and bicyclists are permitted on facilities at or near each end of such bridge, and the safe accommodation of bicyclists can be provided at reasonable cost as part of such replacement or rehabilitation, then such bridge shall be so replaced or rehabilitated as to provide such safe accommodations." (23 U.S.C. Section 217)

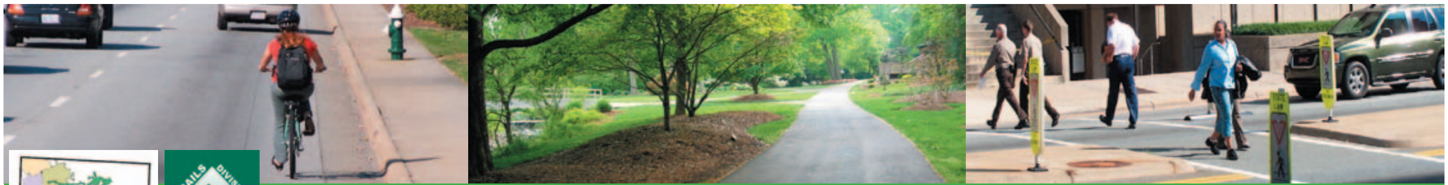
In the case of controlled access freeway projects that impact non-controlled access roadways, it is important to include necessary access for pedestrians and bicycles on the non-limited access roadway. If this access is not provided, pedestrians and bicyclists might lose access to important destinations.

Shared Lane Pavement Markings

The Greensboro MPO should use shared roadway pavement markings as an experimental treatment in appropriate locations in Greensboro. Shared roadway pavement markings include the bicycle symbol and directional arrows on the pavement surface.

Justification

Shared lane pavement markings can be used on roadways where there is not enough space to provide standard, 5-foot-wide bike lanes. They can be used to mark bike routes, show the proper direction for cycling on the road and provide a visual cue that bikes are welcome on the road. These markings are particularly useful for connecting gaps between other bicycle facilities, such as bike lanes. Because they do not require as



much paint, these markings are also less expensive than bike lanes. These markings have already been used in cities such as Denver, CO, Gainesville, FL, Chicago, IL, and San Francisco, CA and are currently under consideration for inclusion in the *MUTCD*.

Road Diets

On multilane roadways with excess existing and future traffic capacity, underutilized roadway travel lanes should be removed. This right-of-way space should be used for bicycle and pedestrian facilities. The term “road diet” refers to re-allocating roadway space used as travel lanes to some other purpose, such as bicycle lanes, sidewalks, on-street parking, etc. One type of “road diet” refers to changing a four-lane, undivided roadway cross section into a cross section with one through-lane in each direction, a two-way left-turn lane, and bicycle lanes.

Justification

This type of treatment can improve (or at least maintain) traffic flow because it removes left-turning traffic from the inside travel lane. While the feasibility of the treatment depends on traffic volume, studies have shown that it does not reduce the capacity of roadways with ADT counts of up to 20,000 vehicles per day (1, 2). This type of conversion also has proven benefits in terms of pedestrian, bicycle, and motor vehicle safety (1, 2, and 3). Pedestrians who are crossing the street would have less motor vehicle lane distance to cross, and median refuge islands can be constructed in the center-turn lane area at appropriate crossing locations.

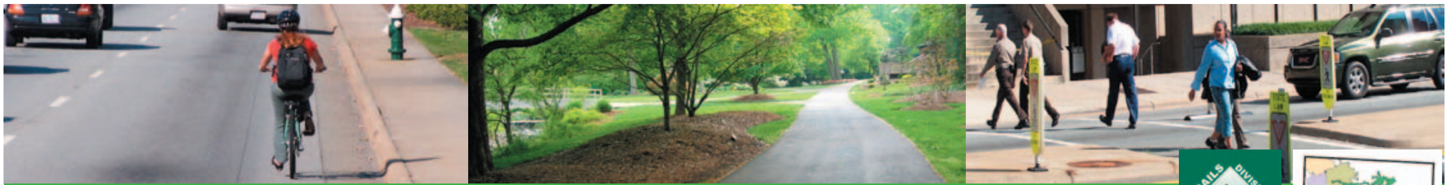
1. Huang, H.F., Stewart, J.R., and Zegeer, C.V. “Evaluation of lane reduction “road diet” measures on crashes and injuries”, Transportation Research Record, No. 1784, TRB, National Research Council, Washington, D.C., pp. 80-90, 2002.
2. Huang, H.F., Stewart, J.R., and Zegeer, C.V. “Evaluation of Lane Reduction “Road Diet” Measures and Their Effects on Crashes and Injuries,” Highway Safety Information System (HSIS) Summary, Publication HSIS FHWA-HRT-04-082, http://www.hsisinfo.org/pdf/04-082.htm, 2004. Accessed December 2005.
3. Pawlovich, M., W. Li, A. Carriquiry, and T. Welch. “Iowa’s Experience with ‘Road Diet’ Measures: Impacts on Crash Frequencies and Crash Rates Assessed Following a Bayesian Approach”, Submitted for review to Transportation Research Record, http://www.dot.state.ia.us/crashanalysis/pdfs/trb_roaddiet_papersubmission_08012005.pdf. Accessed December 2005.

Issues to Consider for Signed Bicycle Routes

A bicycle route is a bikeway or system of bikeways (roadways, bicycle lanes, shoulders or pathways) that is designated with appropriate directional and informational route markers. Bicycle routes can serve recreational, commuting and neighborhood trips. The reason for designating a bicycle route is to provide guidance, connection and continuity.

Justification

Signing of shared roadways indicates to cyclists that there are particular advantages to using these routes compared to alternate routes between the same places. This means that the responsible agencies have taken



action to ensure that these routes are suitable as shared routes and will be maintained as such.

There are several reasons for designating signed bicycle routes:

a) The route provides connectivity to other bicycle facilities such as bicycle lanes and shared use paths.

b) The route extends along a series of minor streets that
   - would be difficult to follow without signs,
   - provide a relatively direct through route between major destinations, or
   - lead to an internal neighborhood destination such as a park, school, trail access point or commercial district, that would be hard to find otherwise.

c) The route is preferred among other potential routes between major destinations; it may include specific improvements made to enhance bicycle safety and convenience, or may have conditions more favorable to bicycling.

d) In rural areas, the route is preferred for bicycling due to low motor vehicle traffic volumes, high scenic and destination values and/or the presence of a paved shoulder.

Routes that meet any of these criteria should be evaluated to determine if the conditions along the route are adequate for bicycling. If the route is determined to be suitable, bicycle route signs can be installed along the route. Typically, a bicycle route should be a minimum of 1 mile in length unless it serves as a short neighborhood connecter.

Issues to Consider for Pedestrian and Bicycle Overpasses and Underpasses

Overpasses and underpasses are sometimes necessary to facilitate pedestrian and bicycle crossings, although at-grade crossings are preferable in most situations.

Justification

Pedestrians and bicyclists can rarely be convinced to use a poorly-located crossing and as a result, convenience is essential in designing overpasses and underpasses. Grade-separated crossings should be provided within the normal path of pedestrians and bicyclists wherever possible. Topography should be a major consideration in determining whether an underpass or overpass is appropriate. If the crossing requires pedestrians to use switchback ramps and cover considerably more distance (at a significant up-grade or down-grade) than the at-grade crossing, it may be more advantageous to improve the at-grade crossing instead, depending upon traffic conditions. The best overpasses and underpasses are those that take advantage of the existing topography to make a direct and efficient crossing that eliminates conflicts between pedestrians and vehicular traffic. Grade separated facilities that take advantage of surrounding topography also tend to be less expensive to construct.